Abstract

Mankind has used buried infrastructure for eight millennia, initially for clean water and safe disposal of sewage. Over the years, much has been added to this infrastructure, particularly to cater for our modern need for energy and telecommunications. There are currently about 2 million kilometres of underground cables and pipelines in the Netherlands, a combination of water, sewerage, gas, oil, electricity and telecommunications.

Dutch Cadastre is responsible for the nation's registration of parcel boundaries (cadastral map) and the legal status of parcels (land registry). For cable and pipeline, the current practice of registration (registration of rights by means of legal notification) only indicates a factual situations, but whatever rights, restrictions and legal notifications are still established on the surface parcels.

The legal status of such factual situations with a 3D component is not being able to be represented in the most efficient manner under the current 2D space. The introduction of the third dimension is deemed necessary, so as to be able to provide efficient means to register and to provide the legal status of these objects as in the real world.

Recent Dutch Supreme Court ruling (Hoge Raad, 06/06/2003: 36075; kabel is onroerende zaak) about the immoveable character of underground cables and pipelines further reinforced the need for Dutch Cadastre to evaluate a systematic, efficient means for the cadastral registration of the rights of both the networks as a whole, also on the intersecting parcels of land.

Keywords: Dutch Cadastre, parcel, cable and pipeline, 2D space, 3D component.

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1. INTRODUCTION

According to thefreedictionary.com, **cadastre** is originated from Latin's '*capitastrum*' (a register of the poll tax) and Greek's '*katastikhon*' (line by line). UNECE 2005 defined it as "*a set of records about land that consists of two parts: a series of maps or plans showing the size and location of all land parcels together with text records that described the attributes of the land. The function ... is to collect and make available graphic and textual information in support of title registration, property valuation and land resource management*".

This section presents the topic of this research and the event that brought about the new needs in the registration of cable and pipeline. Section 1.1 begins with a brief introduction to roles and functions of the Dutch Cadastre. Section 1.2 touches on the general limitations on the current registration of cable and pipeline and the last section (1.3) ends with the event that brought about the new needs.

1.1 Dutch Cadastre

The Kadaster (Dutch Cadastre, Land Registry and Mapping Agency) is responsible for the registration of parcel boundaries (cadastral map) and its legal status (land registry) in the Netherlands. Kadaster.nl listed its functions as "*collect information about registered properties in the Netherlands, record them in public registers and in cadastral maps and makes this information available to the members of the public, companies and other interested parties in the society*".

Kadaster collects details of goods in the Netherlands subject to compulsory registration, stores these in public databases and cadastral maps and makes these available, for a fee, to companies, private individuals and other interested parties (kadaster.nl).

The current practice of cadastral registration by Kadaster comprises of the spatial LKI (Information system for Surveying and Mapping or Landmeetkundig Kartografisch Informatiesysteem) and administrative AKR (Automated Cadastral Registration or Automatisering Kadastrale Registratie). LKI is the 2D geo-DBMS for maintaining the geometry and topology of parcels, while AKR is the DBMS for maintaining legal and other administrative data. A unique parcel ID provides the required linkage between these DBMSs.

LKI stores the large-scale topographic and cadastral data (geometric database) in an Ingres database using OME/SOL (Object Management Extension/Spatial Object Library). Legal and other administrative data related to the parcel (administrative database) are maintained in an IDMS (Integrated Database Management System) database on IBM mainframe.

To provide an environment for the easy access to all data for analysis, query and filter, these 2 databases are loaded monthly into a single Ingres DBMS. A generic query tool has been incorporated for analysis and performing consistency checks on the cadastral source data to improve its quality.

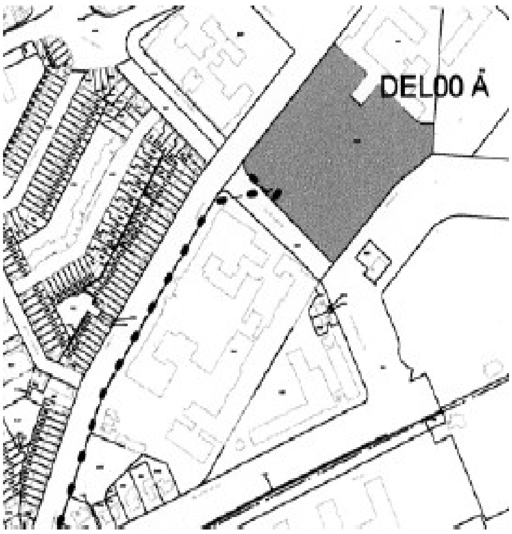
1.2 Current Registration of Cable and pipeline

Dutch landowners are obliged under the Administrative Law (Belemmeringenwet Privaatrecht) to allow the construction of utilities cable or pipeline for public purposes. These can be the electric or telecommunication cables, water, oil and gas (or even sewage) pipelines. The utility operators acquired these rights via wayleave [5]. UNFAO (Food and Agriculture Organization of the United Nations) defined wayleave as “*the right acquired in order to route something (e.g. gas and other pipelines and electricity and other cables) through the land of another, ... is in effect an easement*”.

Within the administrative AKR, proprietary rights on linear constructions such as cable and pipeline are registered via wayleave (opstalrecht) or legal notification. AKR code 'OS' represents rights to the dominant owner (person who enjoys the benefit of the easement) and 'EVOS' the ownership rights of the servient owner (owner of land subjected to the easement). Legal notification (Object Belemmering), on the other hand, is a legal indication in the cadastral registration that indicates that the land is subjected to restriction. The usual legal notifications are: BZ (Zakelijk Recht als art.5 lid 3b van Belemmeringenwet Privaatrecht), OL (Opstalrecht Leiding) and OB (Ondergronds Bouwwerk or underground construction). BZ is a special private right under the Administrative Law, OL the easement for pipeline and OB indicates an existence of an underground object. Nevertheless, there is also the TC tag, for telecommunication network under the Telecommunication Act, which provided some sort of indication within the administrative database. In the case of restriction or rights affected only part of the parcel, another suffix 'D' is added to the code (e.g. OLD).

Current cadastral registration use 2D parcels to register ownership rights, limited rights and public law restrictions on land. The registering objects are parcel, part of parcel and apartment. Factual 3D objects such as cables and pipelines cannot be defined as cadastral objects, thus cannot be used as a base for registration. The notary deed used for the registration may contain an analogue drawing mapping the object. When provided with such analogue ‘network map’, the physical extent of the object (for example cables) can be shown on the cadastral map. Under the current system, the inclusion of digital 3D drawing is not possible.

Fig.1: Sample cable network plan attached to the registration deed.



Although the Dutch Kadasterwet (Law on the cadastre) requires that existing parcel to be subdivided whenever there is the transfer of ownership, establishment of rights or restrictions involving part of the parcel, the formal creation of subdivided parcel in the cadastral system may not happen months after the notary deed had been registered in the public register. As an interim measure, an administrative number is created for the part of parcel (old parcel number with a suffix 'D', e.g. D001, D002 etc. for multiple undivided parts) in the administrative database was, but the part of parcels are in fact still one (original) parcel on the cadastral map.

This method of administrative registration on 2D parcels can only provide limited amount of information, given rise to the following limitations:

- cable and pipeline are partitioned by the many intersecting surface parcels
- proprietary rights on cable and pipeline are registered only on these intersecting parcels, thus these rights provide no information about the whole object, its spatial information etc.
- potential source of data inconsistency as attributes on the cable and pipeline (owner, date of deed etc.) are not recorded on the object itself, but on the numerous intersecting parcels
- data pollution whenever a related surface parcel is subsequently subdivided, all the subdivided parcels are imposed with the original restrictions as the exact location of the cable and pipeline is not known.
- hinder the proper utilization of subsurface space
- proper management and maintenance of underground utilities
- appropriation of compensation from the rights holder to the affected landowners (who and how much).

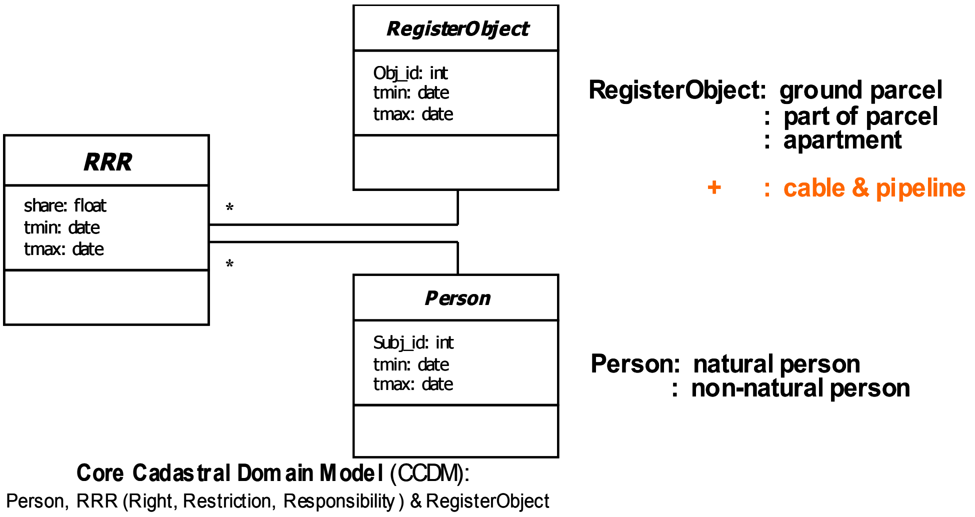
1.3 Supreme Court ruling Nr. 36.075 dated 6.6.2003

The recent Dutch Hoge Raad (Supreme Court) judgement of June 6, 2003, No. 36,075 stipulated that "*een kabelnet is een zelfstandig overdraagbare onroerende zaak*" (a cable television network is an independently transmissible property matter [*7*]). This ruling further reinforced the need for a cadastral registration of the rights on both the networks of cable and pipeline as a whole, and on the separate parcels of land in which they are situated. Besides, there is also the need for security of the public provisions, from being damaged by ground excavation works. And it also facilitates the privatization of the utilities companies.

The below UML (Unified Modeling Language) class diagram illustrated the relationships between the real property objects (RegisterObject, either parcel, part of parcel or apartment) and Person (natural person or non-natural person) via RRR (right, restrictions, responsibility) [*17*]. This data model is the foundation of most of the land administration. After Nr. 036.075, the Object list now also includes cable and pipeline. Consequently the following CCDM (core cadastral domain model) illustrated the new requirement: cable and pipeline as the 4th register-able object.

A person can be associated to any number of RRRs (multiplicity '*'), while a RRR can involves only 1 person (multiplicity omitted, indicates '1'). Similarly, a registerobject can be associated to any number of RRRs, but a RRR can involves only 1 registerobject. There is no direct relationship between Person and RegisterObject, but only via RRR.

Fig.2: Data model of the current registration.



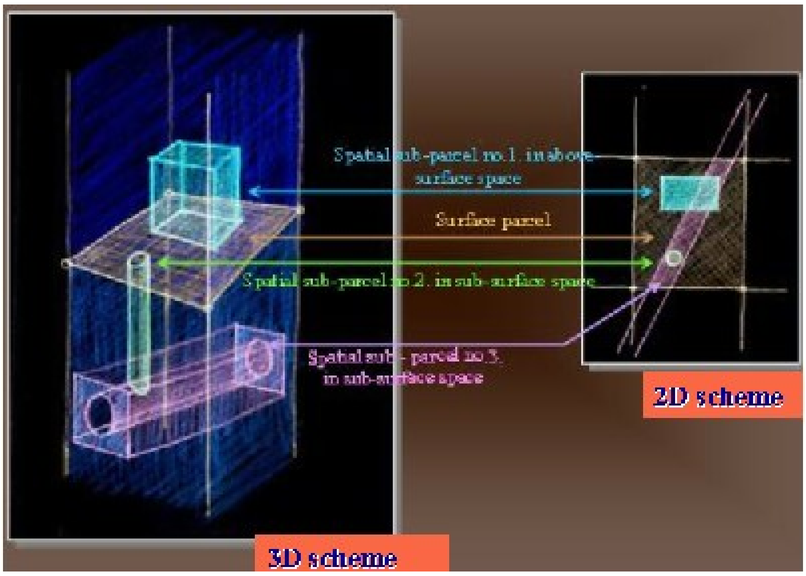
1.4 Needs and requirements for 3D registration

In area with an intensive use of land, there is growing demand to utilize space above and under the surface, resulting in multi-level use of land. This leads to complex property situations whereby constructions are often overlapping or even interlocking each other.

The space we live is in 3-dimensional space, commonly known as length, width and breadth. Modern Cartesian coordinate system specify the position of a point or object on a surface using 2 intersecting axes as measuring guide, hence it is called 2-dimensional (in x, y). When another z-axis is added, it provides a sense of third dimension (hence added up as 3-dimensional, in x, y, z) of space measurement (wikipedia.org).

It is often difficult to translate the information in total during the transformation from one system to another. When the legal status of wayleave is transformed from the real world to 2D plane (either by descriptive texts or drawing), ambiguities often arise. Moreover, the issue is further complicated by the fact that they are often buried underground. Picture is said to be worth a thousand words, yet a 2D drawing could not completely portray reality in 3D. So as cable and pipeline are themselves not cadastral objects, they can only be indicated by symbols or dashed line (as topographic features). The geometric quality cannot be maintained and there is limited information spatially or about its attribute values. *Fig. 3* below illustrated the limitations when depicting 3D information in 2D space.

Fig.3: Complications when projecting from 3D scheme to the respective 2D scheme [14]



From the cadastral perspective, the mapping of the 4th register-able object (cable and pipeline) should also meets the following standard of quality (as for parcel, part of parcel and apartment):

- geometric quality (positional accuracy)
- completeness, with all relevant information
- attributes accuracy
- consistency, in maintaining the actual topology and between the map and the cadastral registration (stored in a separate database)
- up-to-date depiction of the current legal situations

Traditional 2D cadastre is often not able to reflect the real world spatial information about the rights of cable and pipeline. Below [*Fig.4*] are the results of the queries on the legal status of the parcels intersecting with 2 existing pipelines [*10*], which clearly showed the limitations on the current system. These limitations with respect to cable and pipeline are:

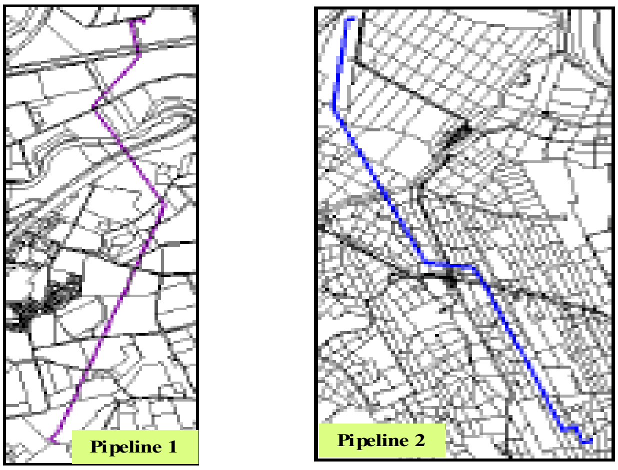
- the accessibility of the registration in 3D situations not optimal in the absent of digital 3D representation
- rights being registered in a form that not comparable with the actual usage
- different ad hoc solutions are being adopted for comparable situations

These limitations in turn often lead to following complications:

- the physical object itself or its attributes are not stored, therefore could not be an object for analysis (query within the Kadaster databases)
- the physical object is arbitrary divided into parts in order to match that of the intersecting surface parcels
- redundant information sometimes lead to inconsistencies as the same information is being repeated in each and every intersecting parcels
- database becomes polluted as uncertainties in the spatial location caused all suspecting intersecting parcels to being registered, more so during subdivision (all being registered as not sure which new parcels are involved)

The following case study clearly demonstrated such limitations. Normally it is not possible to query the legal status of the intersecting parcels (with the pipeline), as spatial information of the physical objects is not maintained in the cadastre. This investigation is made possible after importing the external network information into the database.

Fig.4: Case study on the effectiveness of the current cadastral registration of utility pipeline [10]



#	Descriptions	Network 1		Network 2	
		Quantity	%	Quantity	%
1	No of parcels intersecting with the projected pipeline	42		43	
2	No of parcels correctly tagged (proprietary rights identified)	1	2%	0	0%
3	No of parcels (from 2) correctly indicated ownership rights	0	0%	0	0%
4	No of parcels (from 2) correctly indicated with wayleave	1	2%	0	0%
5	No of parcels correctly identified with Legal Notification	27	64%	38	88%
6	Type of Legal Notification (mainly)	BZ(D)		OL(D)	

This table above showed that information obtainable from the cadastre is fragmented, with only the rights on the intersecting parcels are being registered. A right might had been established to enable the utility operator to lay and hold the cable or pipeline on a parcel (via Legal Notification), but not all intended parcels are 'tagged' and the exact spatial location of the object is still not known, either in 2D or 3D space. The network itself also cannot be query for analysis.

The legal status of factual situations with a 3D component is not being able to be represented in the most efficient manner under the current 2D representation. The introduction of the third dimension is deemed necessary, so as to be able to provide efficient means to register and to provide the legal status of these objects as in the real world.

2. PROJECT SCOPE

Supreme Court ruling Nr. 036.075 demanded Kadaster to evaluate means to register cable and pipeline in a systematic and efficient manner, yet in consistent with current registration of the other register-able real property objects such as parcel, part of parcel and apartment. This new demand centred on how to register whatever proprietary rights at cable and pipeline directly on the object, not indirectly via the surface parcel.

This section defines the demand upon Kadaster to evaluate the means to register cable and pipeline as a register-able real property, in a systematic, efficient yet consistent manner with current practice. Section 2.1 starts with the problem definition, follow by Section 2.2 which states the objective, goal, scope and research topics. Section 2.3 presents the overview of the processes involved, required tools and data. This section stops at Section 2.4, which details the special considerations that limit how the research can proceed.

2.1 Problem definition

The ruling of the Dutch Supreme Court (Nr. 36,075 of 6.6.2003) on the immovable character of underground cable and pipeline sets new demands on cadastre registration. Issues confronting the Kadaster are the definition of the various rights involved in such cross-boundary underground objects and how to register these rights.

The current practice of registration via the attachment of drawings (actually via registration of legal notifications) only indicates a factual situation (existence of underground object below the sub-surface parcel), but whatever rights, restrictions and legal notifications are still established on the surface parcel. The registration of deeds on 2D surface parcels has it limitations for object with 3D situations; it needs an extension to the vertical dimension in order to be able to register all kind of property situations that occur in this modern world.

2.2 Objective

The objective of this research is to provide insight into the feasibilities and limitations of the current Dutch Cadastre, in respect to the registration of cables and pipelines in the cadastral databases.

Goal

Study the feasibility of registering the legal status of wayleave (cable and pipeline) as a real estate property into the cadastral databases by expanding into the 3rd dimension, leading to a pilot system.

Scope

The scope of this research is to develop a comprehensive data model, incorporating the 3D property situations of cable and pipeline into the present CCDM, in accordance to the current and foreseeable future requirements of Dutch Cadastre. It includes the following aspects:

- Study the current cadastral registration in order to incorporate the proposed 3D situations;
- Design a data model suitable for registering the proposed 3D situations;
- Evaluate the system architecture (computer hardware, software and data structures) required to support the proposed 3D cadastral registration;
- Develop the prototype (to manage the databases and visualization) and test.

Research Topics

The scope of this research is limited only to the following aspects:

- How to extend cable and piping data into core cadastral domain model;
- How to geo-reference piping – relative and / or absolute height;
- How to register piping networks as a whole, and / or also in each separate parcels where it is situated
- How to organize and manage the databases (LKI, AKR, AHN and piping) – a single geo-DBMS or several DBMSs.

2.3 Processes and data

In principal the process flow is to integrate the concept of 3D cadastre [*9*] into the works of Oracle 10g Topology [*4*] and 3D Visualization of Urban Pipelines [*3*]. Then to access the geo-DBMSs via a CAD front-end (Bentley MicroStation). The required data for testing are the cadastral parcels together with their associating administrative data, also the cable and pipeline network data.

Processes

a. Develop the conceptualized data model
b. Organize geo-information using Oracle Spatial
    - load spatial data (cadastral data)
    - define geometries of cable and pipeline
    - index and query spatial data
c. Create MicroStation GeoGraphics project
    - collect tabular and graphical data
    - clean and collect graphical data
    - create a MicroStation GeoGraphics project
    - analyse data
d. 3D visualization of parcels, cable and pipeline

Data

a. Cadastral parcel map content (LKI)
    - parcel boundaries
    - parcel numbers
    - outline of main building and reference point
    - street names and house numbers

b. Administrative information (AKR)
    - names, address, gender, birth date of the official owner
    - parcel number
    - area
    - businesslike rights
    - legal notifications
    - additional registration (e.g. Hereditary tenure)

c. Terrain and building heights from AHN (Actual Height Model of the Netherlands)
d. Cable and pipeline dataset

2.4 Special considerations

Current registration

If the proposed 3D situations are to be register-able under current cadastre, theirs legal status have to be translated in such a way that it can be registered in the current cadastral registration as well.

Whole & part registration

The registration of cables and pipelines should be able to register the rights of the networks as a whole, and also on each parcel that they situated.

Representation of piping segments

Networks of piping shall be represented as line segment type with relative height (depth from ground level), only nodes with (x,y,z & depth).

3. REALISATION OF A 3D REGISTRATION OF CABLE AND pipeline

Traditional cadastral registration of rights is always 2D in nature, based on surface parcel. It is unable to reflect the spatial aspect of such rights completely. On the other hand, the conceptual development of the 3D cadastre in conjunction with current technical progress is shown to meet the required needs of clear definition of proprietary rights in various property situations.

Section 3.1 to 3.3 briefly introduces the various concepts of 3D cadastre, ranging from the full 3D system, hybrid variants and also the 3D referencing system. Section 3.4 provides the rationale in choosing the 2D/3D hybrid system of registration of 3D physical object as the preferred choice.

The use of standardized CCDM served to provide an extensible basis for the efficient and effective cadastral system development basing on a model driven architecture. This avoids the need to repeat the process of reinventing and re-implementing the same functionalities. CCDM also provides the common communication platform within the various parties involved using shared ontology implied by the model.

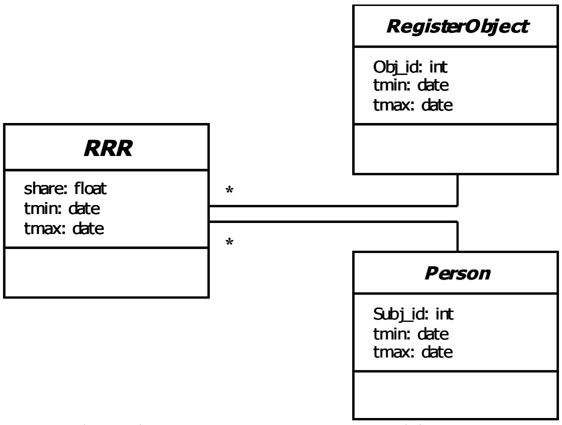
Several CCDM versions have been developed, adjusted each time based on the discussions at the various workshops, and the consultations with several countries all over the world. From the well-known concept of Parcel, Person and Right, CCDM has been evolving ever since the first version (Noordwijk 02) was presented in September 2002. The current version is called 'Moscow 05', it has three core classes: Person (also called Subject), RegisterObject (e.g. parcel) and RRR (right, restriction, responsibility). The various UML class diagrams, representing the various cadastral conceptual models have all been adapted accordingly.

3.1 Full 3D Cadastre

The real world is being partitioned into 3D volume parcels, representing the 3D proprietary rights. In order to support this hypothetically ideal and final solution, the legal basis, real property transaction protocol and cadastral registration should be in place for the establishment and conveyance of 3D rights. In this approach, rights are no longer established on parcels, but on well-defined volume parcel.

The same UML data model explained in Section 1.3 is still applicable, differs only in the way the object is being defined. The cadastral objects are defined in 3D (as 3D parcel), with rights related to the 3D parcels. There shall be no relationship between surface parcels and the 3D physical objects, as both are not represented. There are 2 variants within the full 3D cadastre. First being the combination of infinite parcel column (traditional extend of ownership from 'hell' to 'heaven') and volume parcel (bounded parcel). In the second variant, all should be in the form of well defined and bounded volume parcels.

Fig.5: Main object classes in the current data model [2, 17]



Core Cadastral Domain Model (CCDM):
Person, RRR (Right, Restriction, Responsibility) & RegisterObject

The implementation of this proposed solution is rather impractical at this stage. The concept of 3D volume parcel poses a serious challenge on the traditional doctrine of land ownership as cone down to the centre of earth. To define the extent of ownership in the vertical plane required extensive and complicated overall 3D land title settlement prior to cadastral mapping. On the legal aspect, a change in the civil code is required, but it itself is a lengthy process. Furthermore, current DBMSs support few geometry or topology functions in 3D. This is definitely a mammoth and costly task.

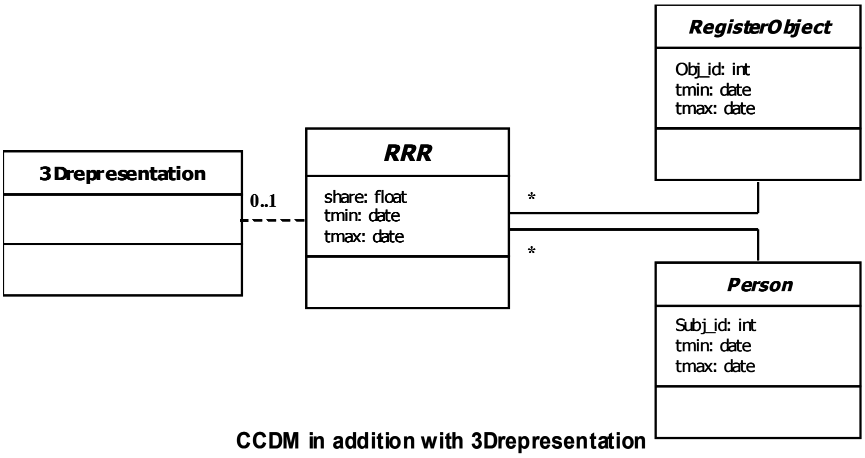
3.2 2D/3D Hybrid

The 2D cadastre is being maintained in addition to registering the factual situation in 3D space by registering 3D objects within the 2D cadastral registration. There are 2 options to register 2D parcels and 3D situation within one system. First being registration of 3D right-object defined by the surface parcel bounded by the upper and lower limits. Second being registration of 3D physical-object, i.e. by registering the 3D physical object itself (defined by its geometry and attributes).

The same UML class diagram as in Section 1.3 (*Fig.2*) is still applicable for this alternative, but there is an addition class of 3Drepresentation. This 3Drepresentation can be either the volume to which a person is entitled (registration of 3D legal space) or a physical object itself (registration of 3D physical object).

3D legal space is different from 3D physical object as it is an abstract (non-visible) object. Currently there is no clear definition of 3D legal space for cable and pipeline. Registering 3D physical objects meets the requirement to register itself as 'Object', and the exact spatial location of the object is then available in the cadastral registration (which will also on cadastral map).

Fig.6: General UML class diagram for the 2D/3D hybrid cadastre ([9, 17].



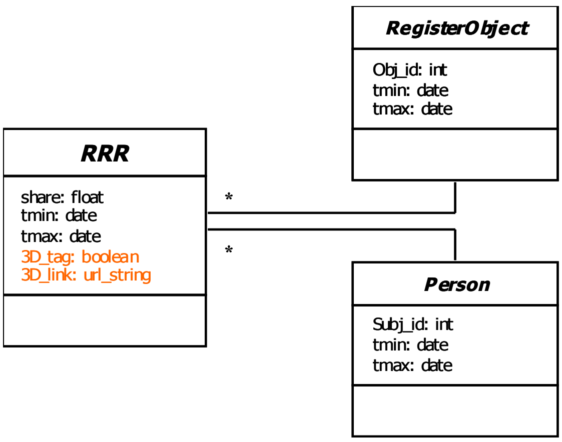
CCDM in addition with 3Drepresentation

3.3 3D Tag

The current 2D cadastre is being preserved, but with additional references linking to 3D analogue or digital CAD drawings. The external reference linking to the 3D situations can be in form of simple tag (3D_tag: boolean, whereby user need to refer to the registration deed for detailed information) or a reference link (3D_link: url_string), to the digital drawing file maintained in the cadastral registration.

This approach is similar to current practise. The tagged drawings can only be accessible via 2D parcel, only for the purpose of viewing. There is no linkage to current administrative databases, thus no query is possible (linkage is only available in the query tool database, refers Section 1.1).

Fig.7: CCDM with addition tag for external reference [9, 17].



CCDM with additional external reference

3.4 Preferred Approach

In consideration of the new requirement (from the Supreme Court ruling) and also to maintain the status quo of the existing juridical and institutional frameworks, the 2D/3D hybrid approach via registration of 3D physical objects has been selected due to the following factors:

- the 2D (parcel) and 3D (cable and pipeline) information are both available, thus can be readily integrated
- more efficient than the current mode of registration where 3D situations are tagged.
- current registration system is still preserved (existing 2D information can still be used)
- current techniques for spatial analysis is still possible under existing DBMSs

The benefits of registering wayleave via registration of 3D physical object are (refers also Section 4) :

- rights are still established on each of the parcels
- provide information on “who are the associated Persons” of those rights
- provide information on “who is the holder (the manager)” of the object
- network can be query as a whole
- relationship between 3D physical object and the intersecting parcels are stored implicitly (obtainable via spatial query)

4. CONCEPTUAL MODEL FOR 3D REGISTRATION OF CABLE AND pipeline

The start of object-oriented problem solving is the construction of a model, which abstracts the details of the underlying problem from its complicated real world. UML (Unified Modeling Language) provides everyone from business analyst to designer and programmer a common communication vocabulary during system development. Class diagram is one of these modeling tools. It contains the classes with their attributes, operations, relationships and constraints. It gives an overview of a system by showing its classes and the relationships among them.

This section attempts to explain the basic ideas behind the development of the data model, right from the standardized CCDM (Section 4.1) and then proceed to the interim approach adopted by [*8*] (Section 4.2). Section 4.3 continues with how and why the refined model is being proposed.

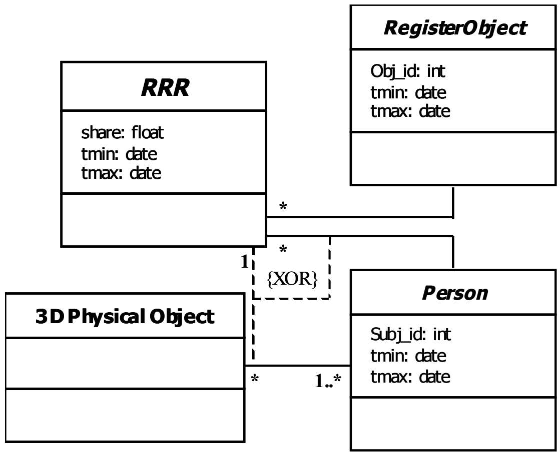
4.1 Core Cadastral Domain Model (CCDM)

The FIG standardized core cadastral domain model is always the convenient starting block in any cadastral modeling. The UML class diagram in Section 3.1 (*Fig 5)* illustrated the relationships between the real property objects (Object, either parcel, part of parcel or apartment) and Person (natural person or non-natural person) via Right (rights or restrictions). This data model is the foundation of most of the land administration.

Objects and Persons have n:m relationships via rights. A person can have rights to more than one real property objects, while an object can be related to more than one person. Every person should at least be associated with one object and vice versa every object should also be associated with at least one person (hence the '1..*' multiplicity).

As explained in the Section 3.4, registration of 3D physical object is chosen as the preferred solution. Thus the conceptual model from [*8*] was being adopted as the building block for modelling this prototype. In order to register cable and pipeline as objects in the real world, the objects themselves should also form the base for registration. In the registration system, both spatial and non-spatial information of the 3D physical objects are stored. Such registration also need to be organized and managed exactly as any other cadastral task.

Fig.8: Data model for the hybrid approach of registration of 3D physical object [8, 17]



CCDM in addition with 3D Physical Object

Beside parcels (RegisterObject), 3D physical objects are also registration objects. Rights (RRR) are still being registered on 2D parcel. The holder of the 3D physical object is a person (or more persons) with a rights on the 3D physical object, by means of limited rights on the intersecting parcels. A holder can has a right over many 3D physical objects (including none) by means of rights on the intersecting surface parcel(s). On the other hand, 3D physical object belongs to at least one holder. However, 3D physical object is not a specialization (i.e. not subset) of real property object, but is being maintained in addition to parcel (parcel is still the basic entity of registration). Another distinction is that having a right on 3D physical objects is only a factual ownership, not really the same as juridical ownership. This is in fact an interim solution when the relevant 3D physical objects are not register-able (not the case for cable and pipeline ever since the Supreme Court ruling).

As both the 3D physical objects and the cadastral objects are spatially defined, their relationships can be determined spatially via spatial overlap functions (thus the relationships need not be maintained explicitly). The juridical relationships between 3D physical objects and the parcels are also need not be maintained explicitly, as the holder of the 3D physical objects should also has some rights over the intersecting parcels.

4.2 Model 1: Extension From Stoter et al's Registration Of 3D Physical Object

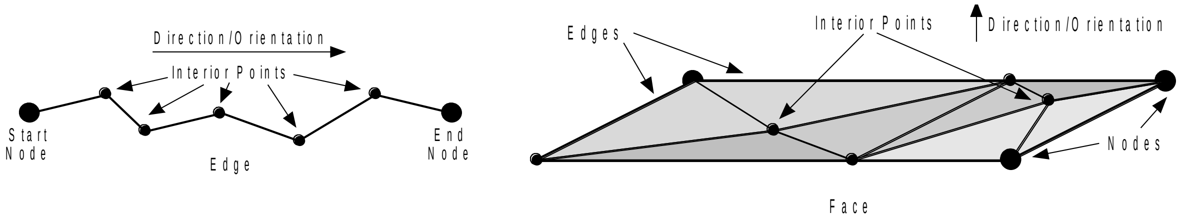
This proposed model is consists of 3 development rings. The outer ring describes the representation of parcel feature and cable and pipeline network from Oracle Spatial topology elements of nodes, edges and faces (there is no face for network data). This outer ring is not generic, but specific to this development platform of accessing Oracle geo-DBMS with MicroStation GeoGraphics as the CAD front-end. The middle ring introduces the register-able objects, while the inner ring is the starting building block adopted directly from [8].

Outer ring

Nodes, edges and faces are the building blocks to represent the real world objects. These real world objects are modelled using feature (Oracle term) or to be precise the topology geometry. Oracle stored these basic topology elements (node, edge, face) as point, line strings, polygons or the combination of all the above.

Node is a zero-dimensional spatial entity that defines a location in 2D or 3D space, with its location defined by a single coordinate tuple. The location of each node must be unique, and it cannot be located in the interior of an edge, but may be located within the interior of a face or within a volume (3D). Edge is a one-dimensional spatial entity that defines a path through 2D or 3D space, its geometry being defined by an ordered collection of 2 or more distinct coordinate tuples. It is bounded by a node at each of the endpoints, with its orientation being defined by an ordered collection of interior points (vertices). A edge may be completely contained within a face or within a volume. Face is a two-dimensional spatial entity that defines a closed area in 2D or 3D space. Its geometry can be defined by a ordered collection of 1 or more edges that bound the face; a collection of 0 or more nodes that are contained within the face; or a collection of 0 or more interior points of an edge. It is bounded by 1or more collections of edges, defining the outer boundary and 0 or more inner boundaries. A face may not intersect or overlap itself or with any other faces. It may meet only along common edges, and / or at common nodes.

Fig.9: The formation of line and face from nodes and edges



For the LKI data (Oracle 10g Topology), Edge is defined by an ordered collection of 2 or more Nodes (actually only the start and end node, in addition to the interior points between the two nodes), while a Node can belong to 1 or 2 Edges. The original LKI cadastral topology has no Node, thus need to be derived. A Face is consists of an ordered collection of 1 or more Edges and 1 Edge can belong to 1 or more Faces. Parcel in this model represents the topology geometry (or feature) of the LKI surface parcel. In Dutch Cadastre, face table and parcel table is having an 1:1 relationship. This parcel is the object for registration, with attributes (information stored about the object) of parcel_id and object type of sdo_topo_geometry. For details about the transformation of the current form of Dutch Cadastre dataset to Oracle 10g format, see Section 5.2 and Section 5.3.1.

For LNW data, the same relationships applied between the Node and Line (Edge renamed as Line as cable and pipeline network is represented by its centreline). There is no Face as network segment data is being represented as polyline defined by its start and end nodes. The collection of Lines with the same serial number (LNW_UIN) is being included as LNW_Network. This is because the network geometry is in fact a series of polylines, to accommodate the insertion of attachment at specified nodes [*3*]. LNW_Network maintains the attributes of the network, which are the network's ID (LNW_UIN) and its geometry type of sdo_geometry. This LNW_Network represents the object (3D Physical Object) for cadastral registration.

The need to introduce LNW_Network class as the aggregation of cable and pipeline in the implementation layer is mainly due to the way cable and pipeline is being represented in MicroStation GeoGraphics. [*3*] constructs cylindrical pipeline using a series of cylinders. This approach can make use of the existing curve surface primitives (JMDL supported only 3D face types of cone (coneElement), extrusion (sweptElement) and BsplineSurface. User defined curve surfaces are not being considered as they are quite complicated, and the required input and subsequent maintenance are rather difficult. By definition, a cylinder can be determined only by 2 variables – a centreline and its diameter. By using basic geometry type of polyline to represent 3D centreline in Oracle Spatial, it offers also an easy way to manage, to implement and required less memory space. Because of this, a 3D polyline record in Oracle Spatial is being represented as a series of 3D polyline segments.

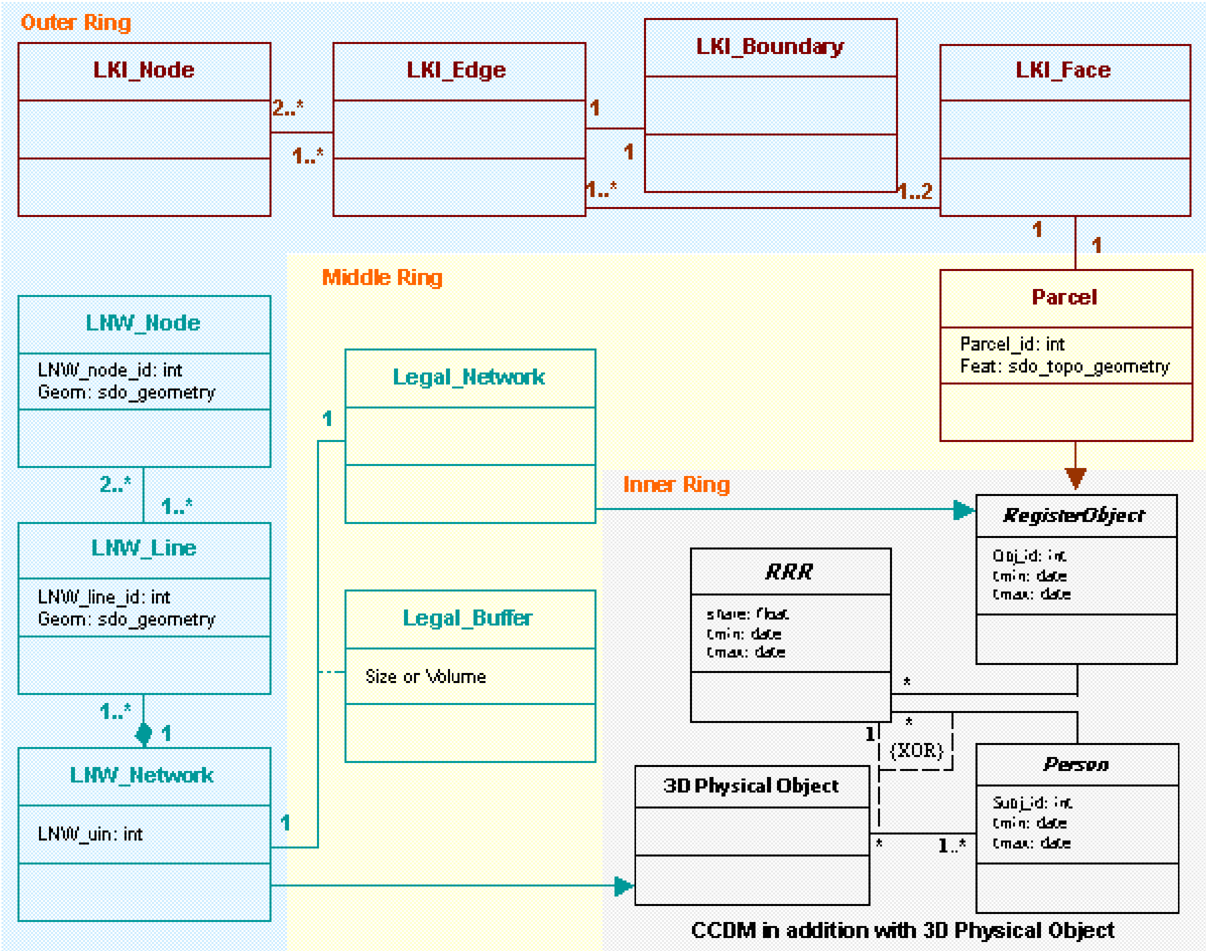
Middle ring

For LKI data, Parcel is the object for registration. This differs with cable and pipeline (in the form of 3D physical object), which is in fact only an object for 'factual registration' (by definition of land, physical object is constitutes only part of the land). In order for it to be able to become an object for juridical ownership registration, Legal_Network is now the legal object. It is formed by associating to LNW_Network via Legal_Buffer, which determined the legal sphere by defining the size or volume around the 3D physical object.

Inner ring

This is actually the interim model proposed in [8] to enable the hybrid approach of the registration of 3D physical object. Details refer Section 3.2 and Section 4.1.

Fig.10: Model for registration of 3D physical object (extension from [8, 17]).



The introducing of the 3D physical object class is actually an intermediate solution. It is not a specialization of real property object, but is being maintained so that the holder of the cable or pipeline (person) can registered his rights. Although it can still relate to an object via an intermediate Legal Network (with association of Legal_Buffer), this model can be further refined by linking 3D physical object directly to CCDM's bject (RegisterObject). The next model avoids the need for the intermediate arrangement of linking 3D physical object directly to person.

4.3 Model 2: Refined Model For Registration of 3D Physical Object

Model 1 is extended from the interim arrangement whereby the proprietary rights of the cable and pipeline operator is being registered on the 3D physical object, in conjunction with registration of whatever limited rights on the intersecting parcels.

A refined model is being proposed for the following reasons:

- 3D physical object is not a subset of the cadastral object
    - not shown on cadastral map
    - not consistent with the standardized CCDM
- Supreme Court ruling Nr. 36.075
    - cable and pipeline as the 4th register-able object

The refined model is basically similar to the previous model, but it proposed to do away with the ad hoc arrangement of maintaining 3D physical object outside the object database. There are still 3 rings of development. The outer ring is identical as Model 1, describes the representation of parcel feature and cable and pipeline network from Oracle Spatial topology elements. Next comes the inner ring, which is quite similar as in Model 1, and then the inner ring that adopts the standardized CCDM as the starting building block. The proposed model is shown in *Fig 11*.

Outer ring

Identical to the outer ring of Model 1, see Section 4.1 for reference.

Middle ring

There is no change in the portion of LKI data formation, while there is a slight modification in the LNW data. Using the standardized CCDM as the starting building block (inner ring), it does away the need to register 3D Physical Object in addition to the normal RegisterObject

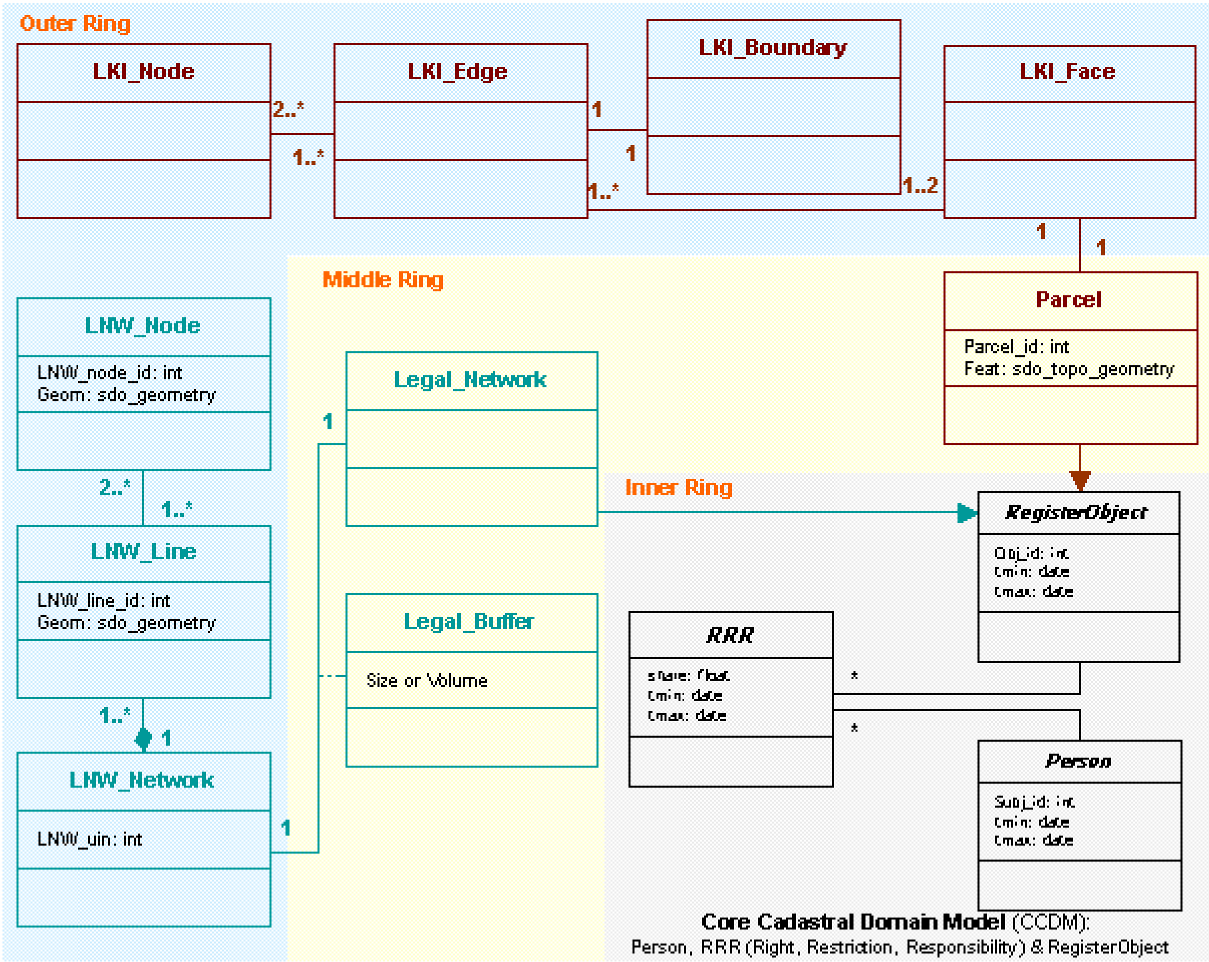
3D physical object can be omitted, or alternatively maintained externally (not in CCDM). In its place, Legal_Network could be a specialization. t is formed by associating to LNW_Network via Legal_Buffer, which determined the legal sphere by defining the size or volume around the 3D physical object.

Inner ring

The starting building block is taken directly from the standardized CCDM, in consistence with the other register-able objects. There is no longer required to maintained the 3D physical object, in addition to the RegisterObject.

This mode of registration is consistent with the registration of parcel, part of parcel and apartment. The relationships between the 3 major classes of Person, RRR and RegisterObject are exactly the same as the standardized CCDM (see Section 1.3 and 3.1).

Fig.11: Refined model for registration of 3D physical object.



5. DEVELOPMENT OF THE PROTOYPE

In order to demonstrate the feasibility of utilizing existing technologies to manage and visualize 3D factual objects such as cable and pipeline into Dutch Cadastre, a prototype has been developed based on the concept proposed by [9] and the results from [4,3]. Basically it comes down to 4 processes, namely:

- LKI parcel transformation
- LNW cable and pipeline preparation
- JMDL compilation and bytecode execution
- 3D visualization

The first 2 sections touch on the required application software, tools (Section 5.1) and data (Section 5.2). It then proceeds to the actual process of development, to put concept into testing. Section 5.3 describes the various processes. Sub-section 5.3.1 lists the transformation of existing Kadaster's LKI data into Oracle 10g format. Sub-section 5.3.2 details the process of getting the cable and pipeline network data into Oracle 10g database. Subsequently the compilation of JMDL program and the final visualization in the CAD front end are being detailed in sub-section 5.3.3 and 5.3.4 respectively. The section ends with examples of spatial analysis with respect to the 'whole and parts analysis' in Section 5.3.5. Lastly Section 5.4 explores another feasible alternative with better optimization.

5.1 Application software and tools

3 types of development tools have been employed in the development, namely the DBMS, CAD system and others. The criteria of selection are first to source from OTB's suite of existing software (including those in use by Kadaster), secondly from those adopted by [4, 3], and lastly freeware readily available in the Internet. The chosen application software and tools are:

- Database
  - Oracle Spatial 10g
- 3D Graphics
  - MicroStation GeoGraphics 2004 edition
- Others
  - SQLPlus (command line SQL & PL/SQL language interface)
  - ConTEXT (text editor)
  - PuTTy (client program to run a remote session on a computer)
  - WS_FTP (application to transfer files between local and remote system)

Spatial data is the information about the locations and shapes of geographic features and the relationships between them, usually stored as coordinates and topology. Oracle Spatial, an integrated set of functions and procedures enabling spatial data to be stored, accessed and analysed quickly, efficiently within the Oracle database. Other than its status as an industry standard DBMS, Oracle Spatial is being chosen in order to be able to utilise the works of [4, 3]. MicroStation GeoGraphics (MS GG) is the CAD front end in [3]. MS GG is an extension of the CAD software MicroStation, with functions specific for geo-information and for connection to Oracle Spatial.

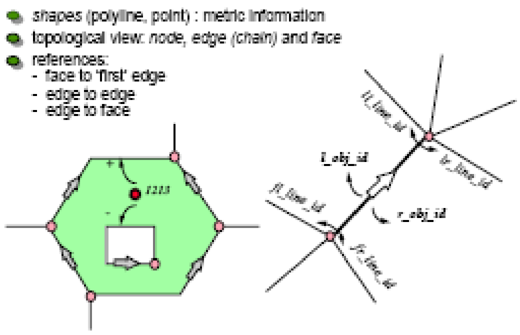
5.2 Data

There are 2 types of data being required for this project. LKI (Information System of Surveying and mapping) and LNW (LeidingNetWerk) for cable and pipeline. The original LKI dataset from the Kadaster based on winged-edge representation needs to be converted into the corresponding Oracle topology of elements type of nodes, edges and faces. As about LNW dataset, the data structure of [*3*] is adopted with minor modifications.

<u>LKI Dataset</u>

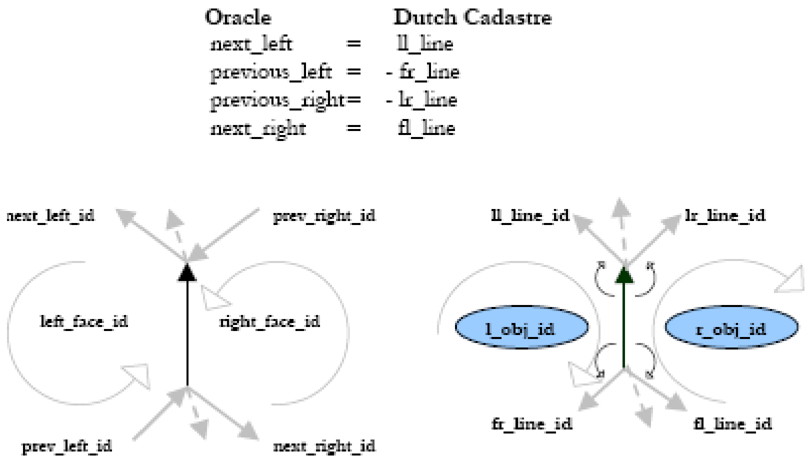
LKI used the 'chain-method' to store the topology of area features in boundary and parcel tables. The advantages (over data type polygon) are: allows calculations on correctness of topology on re-surveyed boundaries; able to relates attributes to the boundaries between parcels, avoid duplication on coordinates, prevent forming of gaps and overlaps between parcels and enables classification of boundaries (administrative or political divisions). The relationship between the edges is maintained using the winged edge structure (Baumgart, 1975 [*12*]), whereby parcel boundaries, parcels themselves are edges and faces in the topology. These edges contain references to other edges, which can be used to form the complete boundary chains (parcels). Each parcel has exactly one reference to one of the surrounding boundaries and one reference to a boundary of each enclave.

Fig.12: Winged-edge topology model in the spatial database of the Dutch Cadastre [16]



As the basic topology elements in Oracle are nodes, edges and faces, and there are small differences in how the winged-edge model is being represented in Oracle and the Dutch Cadastre, the original LKI dataset required conversion (mainly that Oracle has explicit nodes, process refer Section 5.3.1).

Fig.13: Winged-edge representation in Oracle and Dutch Cadastre [4].



The detailed definition of original LKI boundary and parcel tables are rather extensive and will not be duplicated here [15]. Basically the description of the corresponding nodes, edge and face (also feature) table are as follow:

```
SQL> desc lki_node;
 Naam                                      Null?    Type
 ----------------------------------------- -------- ------------------------
 NODE_ID                                            NUMBER
 EDGE_ID                                            NUMBER
 FACE_ID                                            NUMBER
 GEOMETRY                                           MDSYS.SDO_GEOMETRY

SQL> desc lki_edge;
 Naam                                      Null?    Type
 ----------------------------------------- -------- ------------------------
 EDGE_ID                                            NUMBER
 START_NODE_ID                                      NUMBER
 END_NODE_ID                                        NUMBER
 NEXT_LEFT_EDGE_ID                                  NUMBER
 PREV_LEFT_EDGE_ID                                  NUMBER
 NEXT_RIGHT_EDGE_ID                                 NUMBER
 PREV_RIGHT_EDGE_ID                                 NUMBER
 LEFT_FACE_ID                                       NUMBER
 RIGHT_FACE_ID                                      NUMBER
 GEOMETRY                                           MDSYS.SDO_GEOMETRY

SQL> desc lki_face;
 Naam                                      Null?    Type
 ----------------------------------------- -------- ------------------------
 FACE_ID                                            NUMBER
 BOUNDARY_EDGE_ID                                   NUMBER
 ISLAND_EDGE_ID_LIST                                MDSYS.SDO_LIST_TYPE
 ISLAND_NODE_ID_LIST                                MDSYS.SDO_LIST_TYPE
 MBR_GEOMETRY                                       MDSYS.SDO_GEOMETRY

SQL> desc lki_feature;
 Naam                                      Null?    Type
 ----------------------------------------- -------- ------------------------
 OBJECT_ID                                          NUMBER
 FEATURE                                            MDSYS.SDO_TOPO_GEOMETRY
```

LNW Dataset

The proposed LNW data structure was designed to meet 2 requirements: similar to [3] (so to adopt the JMDL program developed with minimum adjustment) and the needs of the Dutch Cadastre (unique network identifier, network type, etc.). The following table compares the 2 data structures, the first being the original as in [3], the second being the proposed version. The highlighted columns are the vital attributes, and those non-essential columns will be excluded in this implementation (for simplification purpose).

Table_name	Name	Null?	Type	Remark
WATERP	MSLINK	NOT NULL	NUMBER(8)	Primary key for water pipe NODE table.
	COMPONENT		VARCHAR2(16)	Attachment type: hydrant, valve, water meter etc.
	TOP_H		NUMBER(8,3)	Height at top of the pipe.
	BOT_H		NUMBER(8,3)	Height at botton of the pipe.
	PSHAPE		SDO_GEOMETRY	Geometry of node of Gtype=3001.
WATERL	MSLINK	NOT NULL	NUMBER(8)	Primary key for water pipe LINE table.
	START_ID		NUMBER(8)	Start node ID.
	END_ID		NUMBER(8)	End node ID.
	MATERIAL		VARCHAR2(8)	Material type: iron, steel etc.
	DIAMETER		NUMBER(6,3)	Diamter fo pipe.
	TALL		NUMBER(6,3)	0 (only cylindrical pipe)
	BDATE		VARCHAR2(7)	Built date.
	LSHAPE		SDO_GEOMETRY	Geometry of polyline of Gtype 4002.

Table_name	Name	Null?	Type	Remark
LNW_NODE	MSLINK	NOT NULL	NUMBER(11)	Primary key.
	LNW_NODE_ID	NOT NULL	NUMBER(11)	Node ID.
	LNW_LINE_ID		NUMBER(11)	Line ID.
	RL_GROUND		NUMBER(8)	Reduced level (RL) at ground level in mm.
	DEPTH		NUMBER(8)	Relative height ((z of centreline - radius of pipe) - RL_GROUND) in mm
	TMIN		NUMBER(9)	Date & Time of line creation in database (integer in second).
	TMAX		NUMBER(9)	Date & Time of line deletion in database (integer in second).
	GEOMETRY		SDO_GEOMETRY	SDO_GEOMETRY(**3001**, NULL, SDO_POINT_TYPE(x, y, z), NULL, NULL)
LNW_LINE	MSLINK	NOT NULL	NUMBER (11)	Primary key.
	LNW_LINE_ID	NOT NULL	NUMBER(11)	Line ID.
	LNW_ID		VARCHAR2 (5+2+5)	GLNW_KAD_AANDUIDING (KADGEM-SECTIE-NUMBER). KADGEM = NWKxx(xx= 12~27), SECTIE = T,E,G,0 & W (sort of network). **Ignored at this stage as it is inconsistent with the LKI data**.
	LNW_UIN		VARCHAR2 (10)	GLNW_UIN (JAAR + '-' + VOLGNUMBER. e.g. (2005-00012).
	START_NODE_ID		NUMBER (11)	Start node ID.
	END_NODE_ID		NUMBER (11)	End node ID.
	TYPE		VARCHAR2(1)	Type of wayleave (GLNW_TYPE - **G**(as), E(lectra), **W**(ater), **O**(lie), **T**(elecommunicatie)).
	DIAMETER		NUMBER(6)	Diameter of pipe in cm (GLNW_BREEDTE in mm).
	HEIGHT		NUMBER(6)	Height of pipe (rectangular, or cylindrical = 0) in mm.
	BDATE		DATE	Built date (GLNW_DATUM_ONTSTAAN (DATE)).
	LNW_ODATE		DATE	Date declared obsolute.
	TMIN		NUMBER(9)	Date & Time of line creation in database (integer in second).
	TMAX		NUMBER(9)	Date & Time of line deletion in database (integer in second).
	MBR_GEOMETRY		SDO_GEOMETRY	GLNW_BBOX (BBOX). SDO_GEOMETRY(**4003**, NULL, NULL, SDO_ELEM_INFO_ARRAY(1, 1003, 3), SDO_ORDINATE_ARRAY(x, y, z,z1 x,y,z,z1))
	GEOMETRY		SDO_GEOMETRY	GLNW_LIJN_COORD (multiline). SDO_GEOMETRY(**4002**, NULL, NULL, SDO_ELEM_INFO_ARRAY(1, 2, 1), SDO_ORDINATE_ARRAY(x, y, z,RL_GROUND, ….., x,y,z,RL_GROUND))

The following NODE and LLINE tables describes the cable and pipeline information stored in Oracle Spatial (for the description on the attributes, refers previous page) :

```
SQL> desc lnw_node
 Naam                                     Null?    Type
 ----------------------------------------- -------- ------------
 MSLINK                                   NOT NULL NUMBER
 LNW_NODE_ID                                       NUMBER
 LNW_LINE_ID                                       NUMBER
 RL_GROUND                                         NUMBER
 DEPTH                                             NUMBER
 GEOMETRY                                          SDO_GEOMETRY

SQL> desc lnw_line
 Naam                                     Null?    Type
 ----------------------------------------- -------- ------------
 MSLINK                                   NOT NULL NUMBER
 LNW_LINE_ID                                       NUMBER
 LNW_UIN                                           NUMBER
 START_NODE_ID                                     NUMBER
 END_NODE_ID                                       NUMBER
 TYPE                                              VARCHAR2(1)
 DIAMETER                                          NUMBER
 HEIGHT                                            NUMBER
 BDATE                                             DATE
 MBR_GEOMETRY                                      SDO_GEOMETRY
 GEOMETRY                                          SDO_GEOMETRY
```

These are the data that stored the geometry and the required network attributes, some of which warrant more illustration. Firstly, registration of LNW network (as a cadastral task) requires a network unique identifier. Below is the Kadaster's unique network identifier [*Fragment CMDB Leidingnetwerk; 16 November 2005 (voostel), Kadaster, Apeldoorn*] as compared with the current parcel identifier:

Current parcel identifier:

Parcel identifier:
'municipal code' + 'section code' + 'base parcel' + 'index'

As compared with the proposed network identifier:

Network identifier (proposed by Kadaster)**:**
'network municipal code' + 'network section code' + 'serial number'

This is not consistent with current practice (parcel), confusion might arises when the municipal referred by parcels and network are not the same yet both lie within the same administrative district. An alternative network identifier can be as follow:

Network identifier (refined)**:**
'municipal code' + 'section code' + 'serial number' + 'year'

It has been decided to adopt absolute height level defined in the national reference system for this project (Kadaster has no specification on height), over the relative height as this offers the benefits of maintaining data consistency in case of update. The absolute z-coordinate is being used within the geometry to maintain the relationship between surface (at ground level) and the spatial location of cable and pipeline, within the applicable time stamp (tmin & tmax). The 4^{th} coordinate in the geometry of LINE table (centreline) provides the z-coordinate at ground level at that location. In the absent of appropriate height information (e.g. TIN), this should provide enough information to 'raised' the 2D parcel to the surface (so that the different in elevation between cable, pipeline and the parcel can be visualize in the CAD front end). This may not be the optimal solution, but it does provide some height indication to the surface parcels when no appropriate height information is available.

The geometry type of NODE is maintained at GTYPE=3001, though it has not being utilized to store additional information ([3] incorporated additional components for the insertion of the attachment of valve, manhole etc. which are more for engineering purposes). For the LINE table, polyline of GTYPE=4002 is still maintained so as not to complicate the drawing of 3D cylinders using JMDL programme [3]. A minimum bounding box (MBR) is being included to aid query performance.

5.3 Methodology

The process of importing the LKI and LNW datasets into Oracle 10g involved 2 processes. First to transform LKI data, then to prepare the LNW data. The modified JMDL programme is to be compiled before it can be executed within MicroStation GeoGraphics for visualization.

5.3.1 Transformation of LKI data to Oracle 10g format

For simplification purpose, the AKI database is being excluded from this prototype. Three scripts – RETRIEVE.SQL, TOPOLOGY.SQL and FEATURE.SQL from [4] have been used to perform the following transformations:

- retrieve the required datasets from the selected test area (NDH02)
- create a new topology
- load data into node, edge and face table
- create topology geometry tables
- associate topology geometry tables with topology by defining the topology geometry layers
- initialize metadata and create indexes on topology tables
- construct features from nodes, edge and faces

This should be a straightforward task, but the execution had taken much more time than anticipated due to the following reasons:

a. Incompatible software
    - SQLPlus – local SQLPlus works only for single line script, resort to network version after installing a client program called PuTTY.
    - Exceed onDemand – it took a long time to locate the installation program from either the shelves or networks, yet the 2 versions installed failed to work.

b. Incomplete dataset
    - not all tables are being duplicated into the working directory, causing various linkage problems. This is solved by adding the required linkage (kadtest.) to lki_boundary, lki_parcel, lki_parcelover and Test_MUNICIP in RETRIEVE.SQL and TOPOLOGY.SQL.

c. Incorrect test area being specified in the RETRIEVE.SQL
    - miscommunication caused a incorrect municipal code was being used. The provided data was for NDH02 (Nederhemert) but the script specified ECK00 (Eck en Wiel). Commands that expecting a single variable returns with multiple variables.

d. Faulty data being downloaded
    - inconsistencies within the sdo_geometry causing errors such as ORA-04063, ORA-06508 & ORA-06512. It was then decided to download a fresh set of data in another directory (KADTEST to KADNL2), as it might consume too much time to rectify .

5.3.2 Preparation of LNW (cables and pipelines) data in Oracle 10g format

As the search for real data (either in the form of analogue or digital drawing, although Kadaster did provided 4 sets of data at the later stage of development) has not been successful during the development stage, a decision has been made to use simulated data, one for cable and another for water pipeline. Also to make things simple, only cylindrical cable and pipeline are being considered here ([*3*] is capable in handling both cylindrical and rectangular surfaces). The geometry of the 2 simple lines drawn using a CAD software was then inserted into Oracle Spatial database using command operators CREATE and INSERT. Other attributes such as LNW_UIN, Diameter, Height etc. are added in accordingly. The required minimum bounding box (MBR_GEOMETR) was determined via SDO_AGGR_MBR in a temporary table, before update it accordingly in LNW_LINE table. The geometry of NODE and LINE table can be validated using geometry subprogram SDO_GEOM.VALIDATE_GEOMETRY_WITH_CONTEXT. The last step is then to initialize metadata and create indexes, the network data is now ready for further processes (*Appendix B2*).

5.3.3 Compilation of MJAVA source code and execution of bytecode in MicroStation

The JMDL source program PIPSURFACE.MJAVA is being adapted for this research, with slight modification to the naming convention for the corresponding file name, table name, attribute name for diameter, height and geometry.

Before using JMDL in MicroStation, [*3*] listed the following parameters configuration:

- set up the CLASSPATH environment variables – these variables direct Java Virtual Machines and other Java applications for the required class libraries. This path setting can be carried out using command operator SET CLASSPATH. A batch file is being prepared for this operation, to set the appropriate paths for the user-defined library, for Oracle, MicroStation and also for MS GG.
- connect with Oracle database, via Oracle JDBC (Java DataBase Connectivity) thin driver. This is being established within the JMDL program.
- Obtain the value of attribute and coordinates of geometry in Oracle database. This is also being taken care of within the JMDL program.
- Compile the JMDL source program – this has been included in the batch file.

Initially there were problems in defining the appropriate path setting. The manual of [*3*] do not specify the exact paths, so each and every parameter are being established from the error messages encountered during the compilation process. This problem can be avoided if there is proper documentation, or seek prior consultation from the developer (setting in *Appendix B1*).

5.3.4 3D Visualization

Before the bytecode can be executed within MicroStation GeoGraphics, the following need to be included:

- open a template drawing (UNTITLE.DGN) in 3D (3D- V8 DGN)
- set up the appropriate CLASSPATH (classpath search path used to find Java/JMDL classes, similar to CLASSPATH set in previous sub-section 5.3.3)
- attach the required cells element from file (PIPATTACH.CELL) prepared in [*3*]
- execute the compiled bytecode via key-in 'jmdl examples.dgn.lnw' (LNW.MJAVA is the JMDL program file stored in the working directory L:\Project\JMDL\Examples\Dgn).
- load the Spatial Viewer (key-in 'java com.bentley.sdodgn.spatialviewer.SpatialViewer', then connect to the required database by login into the OCI client)
- query the selected table (s).

- adjust for presentation, by means of rendering, extrusion etc.

The CLASSPATH setting within MicroStation is very similar to the path setting as Item 4.3.3 above. As the original LKI parcel has no z-coordinate, it needs to be raised to the ground surface (to show elevation with reference to cable and pipeline). A batch file is needed to re-arrange sdo_ordinate_array, to incorporate the additional z-coordinate.

There are several issues that cropped up during this procedure, some of which are being described here:

a. Incompatible software
    - MicroStation – the first version installed do not work, so another version has to be installed.
b. CLASSPATH setting
    - the appropriate settings were not documented, the same search paths as sub-section 5.3.3 need to be declared as well.
c. Prerequisite of the JMDL program
    - the required polyline linetype must be in the form of GTYPE=4002, this is because there are routines that iterate 4 times within the loop (coordinate tuple of 4). The first cable and pipeline data with coordinate tuple of 3 (x,y,z) need to be adjusted to add in the 4^{th} coordinate (the z-coordinate at ground surface). Procedures in sub-section 5.3.2 need to be repeated accordingly.
d. Parcel data in 2D
    - the 2D parcels were originally designed to be raised to the surface level by assigning the node (LKI parcel) with the 4^{th} coordinates from the nearest vertex of LNW_LINE. This was later abandoned due to lack of resources and time. Instead the LKI_Edge table is duplicated by re-arranging the sdo_ordinate_array, there is adding in a uniform z-coordinates (average ground level). An appropriate alternative should be using the ground level obtained from a TIN surface.
    - the construction of parcel on the fly, from topology instead of geometry. This is also abandoned, as the 2D parcels could not be visualized in 3D space. To add in the 3^{rd} dimension in its present format within the existing spatial functions required tedious programming.

5.3.5 Spatial analysis

A cable or pipeline network is actually consists of a series of line record in Oracle Spatial. It itself do not constitute a well-defined linear object capable for direct analysis. In addition, most of the available spatial operators do not work for 3D or 4D object. Before the topological relationships between parcels and cable or pipeline can be analyse, this prototype require 2 more procedures. First to concatenate the mulitline network geometries into a single geometry, then either to transform the 2D parcels to 4D or to convert the 4D mulitline network geometries to only 2D. Both procedures are not directly available, functions need to be developed.

In short, the processes involved for the conversion are:

- transform 4D network geometries to 2D geometries (as Oracle Spatial geometry subprograms do not always work in 3D or more environment, for example, sdo_aggr_concate works only 2D)
- concatenate the multilines network geometries into a single line geometry
- add buffer to the single line geometry (the projection of 3D cylinder onto 2D plane is the corridor with centreline in the middle and buffer distance of half the diameter)
- determine the intersecting parcels (finding spatial interactions between the 2 geometries - parcels and network)

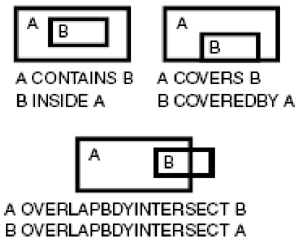
Fig.14: Distance buffer for line.

BUFFER, with width equal to the size of diameter represents network on 2D surface.

Parts analysis

Parts refer to the intersecting parcels, there is the spatial relationships between the 2 objects can be determined using spatial operator SDO_RELATE to evaluate the topological criteria. The topological relationships are in the form of the following:

Fig.15: Topological relationship between intersecting parcels and network.



Spatial relationships:

- CONTAINS, interior & boundary of one object is completely contained in the interior of the other object;
- COVERS, interior of one object is completely contained in the interior or boundary of the other object & their boundaries intersect;
- OVERLAPBYINTERSECT, boundaries & interior of the two objects intersect.

The examples below first identified the identify of each network, and then the object_id of each of the corresponding intersecting parcels can be determined individually (SQL scripts listed in *Appendix B3*)..

```
SQL>  select distinct (lnw_uin) from tmp_buffer group by lnw_uin;

  LNW_UIN
 ----------
      12
      88
SQL>

SQL> select object_id from parcelasgeom_test
          where sdo_relate(geom,
          (select shape from tmp_buffer where lnw_uin = 12),
          'mask=covers+contains+overlapbdyintersect, querytype=window') = 'TRUE';

OBJECT_ID
----------
140969314
140969322
140969320
140969318
140969430
140969429
6 rows selected.
SQL>
```

```
SQL> select object_id from parcelasgeom_test
  where sdo_relate(geom,
    (select shape from tmp_buffer where lnw_uin = 88),
      'mask=covers+contains+overlapbdyintersect, querytype=window') = 'TRUE';

 OBJECT_ID
 ----------
 140969353
 140969355
 140969318
 140969430
 140969416
 140969323
 140969327
 140969325
 140969328
 140969346
 140969315
11 rows selected.
SQL>
```

Whole analysis

The object can be queried as in total (the whole object), example below shows the total length of the cable and pipeline.

```
SQL> select lnw_uin,  sdo_geom.sdo_length (shape, 0.005) from tmp_buffer;

  LNW_UIN SDO_GEOM.SDO_LENGTH(SHAPE,0.005)
---------- --------------------------------
    12                  1046977.85
    88                  1242420.13
```

The second example finds the various attributes of the network – the network unique identifier (LNW_UIN), built date (BDATE), type (G(as), E(lectric), W(ater), O(il) or T(elco)) and diameter. There are multiple groupings (group by) in the query statement because each segment of line has its same lnw_uin, bdate, type etc. A better way is to do away with this multiple storage of same data by storing them only once in another associate table.

```
SQL> select lnw_uin, bdate, type, diameter from lnw_line group by lnw_uin, bdate, type, diameter;

  LNW_UIN BDATE     T   DIAMETER
---------- --------- - ----------
    12 01-DEC-99 W      600
    88 01-OCT-00 E      300
```

5.4 Feasible alternative

An efficient administration of large volume of data requires a 1:1 relationship between object in reality and object in database. The storage of network data in the form of multiple sections of centreline and display as 3D cone surface is certainly not an optimal solution.

3D cylinder may be a good representation for cylindrical cable and pipeline physically in reality, but the extent of land use defined by a cylinder is rather impractical (especially within the sub-surface). A viable substitute may be in the form of polyhedron (3D volume made up of several flat faces). The use of 3D geometrical primitive in a DBMS offers the following advantages [9]:

- one 3D primitive equal to one object (1:1 relationship)
- identifiable as one object by front-end applications (CAD, GIS)
- efficiency in data storage, validation and queries

Nevertheless, to compensate for the lack of 3D spatial functions among the DBMS, the following common functionalities need to be provided [*9*] :

- functions to validate polyhedron
- functions to raise the 2D parcels to the ground surface
- functions that return a Boolean – e.g. intersection
- functions that return a scale – e.g. area, perimeter and volume
- functions that return a simple geometry – e.g. bounding box, centroid

and;

- functions to raise only the intersecting parcels to the ground surface during visualization, with ground level adopts from TIN.

6. CONCLUSION AND RECOMMENDATION

Section 6.1 summarises the work done and the benefits of such registration. Section 6.2 raises the issues related to this project, and Section 6.3 describes the limitations of this prototype. Lastly Section 6.4 provides some pointers for future research.

6.1 Conclusion

Registration of cable and pipeline by means of registration of 3D physical object is proved to be a viable solution, taking into account of the current juridical and cadastral frameworks, as well as the available technologies. Below are the tasks accomplished as compared with the proposed research topics:

Proposed Research Topics	Research Tasks Accomplished
• **How to extend piping data into Core Cadastre Domain Model**	❑ Model 1 (Section 4.2) adopts [8] as the starting building block. Besides parcels (object), 3D physical objects are also registration object (3D physical objects are maintained in addition to parcels) . The only rights a person (subject) is as a holder of the 3D physical object, yet its limited rights are still maintained in the intersecting surface parcels. ❑ Model (Section 4.3) is refined from Model 1. 3D physical object is being maintained directly as a subset of objects, in the manner consistent with the standardized CCDM.
• **How to geo-reference piping**	❑ Cable and pipe are being modelled using Oracle basic topology elements of nodes and lines (edge), representing the network centreline. The geometry of node is defined by geometry type of GTYPE=3001 (3D coordinate tuple in (x,y,z)). The geometry of the line is of GTYPE=4003 (4D polyline with coordinates of (x,y,z, ground level). The z-coordinate is based on absolute height for ease of maintenance and data consistency.
• **How to register piping networks as a whole, and also the individual intersecting parcels.**	❑ Although a single network is represented as a multiple segments of polyline (due to [3]), all the associated segments have a unique network ID (LNW_UIN). The collection of segments with identical network ID constitutes a piping network as a whole. ❑ As both 3D physical objects and parcels are spatially defined, the spatial intersection between the 2 shall reveal the identities of the intersecting parcels.
• **How to organize and manage the databases (LKI, AKR, AHN and Piping)**	❑ LKI and LNW (piping) databases have rather diverse needs and requirements. They are maintained in separate databases, for ease of maintenance and also not to disrupt the existing LKI databases. AKR and AHN data are not integrated within this research due to lack of resources and time. Conceptual wise AKR and AHN databases should also maintain individual.

The proposed prototype demonstrated that the limitations from current registration of cable and pipeline via tagging on 2D parcels (refer Section 1.4) can be improved. The conclusion is that this approach is capable to register and provide the legal status of cable and pipeline in an efficient manner, in accordance to current cadastral registration practice. The benefits in such mode of registration are:

- accessibility of the registration in 3D situations is optimal as digital 3D representation is provided and is easily accessible
- the physical object itself or characteristics of the object are maintained, spatial analysis is now possible
- constructions no longer need to be illogically divided into parts in order to match with the surface parcels
- information associated with construction no longer need to registered on each and every intersecting parcels, but on the object itself. The issues of data redundancy that lead to inconsistency can be avoided.
- database pollution ceased to exist, when the exact the exact identity of each and every intersecting parcels, including the exact spatial location of the object is maintained within the database.

6.2 Project issues

Conceptual wise this research is quite straightforward: to integrate LKI and LNW databases, then to access these databases with a CAD system for 3D visualization. Works on 3D cadastre, LKI data transformation and 3D visualization of pipeline are topics that have been extensively and successfully carried out within OTB itself. Nevertheless, the demand on knowledge and skills to integrate these closely related systems but in piece-meal basis is quite extensive and demanding in nature.

The required resources can be listed as below:

- Dutch Cadastre
- 3D Cadastre
- knowledge in Oracle Spatial and MicroStation GeoGraphics
- Computing skill in SQL, Java and JMDL

Most of the hiccups and delays are organizational in nature. It was rather taxing and time consuming to figure out and then to be able to work around the existing organization structure within the OTB. A centralized data and application software depository centre shall be able to minimize the hassle to locate the matching data and tools. There are various expertises within their respective fields, so it was also a taunting task to seek the appropriate experts for guidance, assistance or consultation.

These limitations can be minimized by the following:

a. Centralized depository of software and development tools
b. Common database project, where all testing data are being maintained with appropriate metadata.
c. Centralized registration of expertise and specialization.

6.3 Limitations in the proposed registration

This project integrated the works of a few individuals, thus is having the following inherent limitations:

- Registration of 3D physical object is only an interim approach. Land by definition included everything that attached permanently with it, thus cable and pipeline are in fact constitute only 'part' of the said land (factual ownership over juridical ownership).
- There is no clear definition of 3D legal space, the exact extent of 'ownership' could not be clearly determined.
- Lack of suitable 3D primitive to represent cable and pipeline as in the real world. A 3D cylinder is in fact a series of 3D cylindrical segments.
- No direct linkage between network data in Oracle and 3D cone surface in MicroStation GeoGraphics. One is stored as centreline while the other represented it as surface.
- Existing DBMSs support storage and indexing of 3D/4D geometry types, but there are few true 3D spatial operators.

6.4 Future direction

Dutch Cadastre within the existing juridical and cadastral frameworks is still basically (surface) land parcel oriented. The 2D/3D hybrid approach of registration of 3D physical object seems to be the most viable solution for cable and pipeline. The network physical construction itself is registered within the cadastral registration, providing it a better insight in its legal status. Nevertheless, registering its legal status by means of land parcels implied that querying the legal status in 3D still require the referencing to the legal status of the intersecting parcels.

This mode of registration can be further enhance with the following improvements:

- clear definition of 3D legal space
- suitable 3D primitives for storage, representation and convenient for spatial analysis
- extend the existing 2D LKI data into the 3rd dimension
- more spatial operators in 3D

References

1. B. Osch (2000), *Cadastral LIS in the Netherlands,* Kadaster, Apeldoorn, the Netherlands.

2. C. Lemmen, P. van der Molen, (2003), *A modular Standard for the Cadastral Domain,* GDMC Publications, October 2004.

3. Du YQ (2005), *3D Visualization of Urban Pipelines,* OTB Research Institute for Housing, Urban and Mobility Studies, Delft University of Technology, the Netherlands.

4. F. Penninga (2004), *Oracle 10g Topology, Testing Oracle 10g Using Cadastral Data,* GISt Report No. 26, Delft University of Technology, the Netherlands.

5. G. Cipparisse (2003), *Multilingual Thesaurus on Land Tenure,* Food and Agriculture Organization of the United Nations, Rome, Italy.

6. H Sandberg (2003), *Three-dimensional Partition and Registration of Subsurface Space,* College of Management, School of Law, Israel.

7. Hemels, S.J.C. Noot (2003), bij : HR 36.075 06-06-2003, *Nederlands Tijdschrift voor Fiscaal Recht*, 1015, p.15.

8. J. E. Stoter (2002), *UML Modeling: From a 2D to a 3D Cadastre,* Delft University of Technology, the Netherlands.

9. J. E. Stoter (2004), 3D Cadastre, PhD thesis, Delft University of Technology, the Netherlands.

10. J. E. Stoter, H. Ploeger (2003), *Registration of 3D Objects Crossing Parcel Boundaries,* In proceedings FIG Working Week 2003, Paris, France.

11. J. E. Stoter, J. Zevenbergen (2001), *Changes in the Definition of Property: a Consideration for a 3D Cadastral Registration System,* In proceedings FIG Working Week 2001, Seoul, Korea.

12. J. E. Stoter, M. Salzmann, *Towards a 3D Cadastre: Where do Cadastral Needs and Technical Possibilities Meets?,* Delft University of Technology, the Netherlands, and Kadaster, Apeldoorn, the Netherlands.

13. J. E. Stoter, P. van Oosterom (2003), *Cadastral Registration of Real Estate Objects in Three Dimension,* URISA Journal, Vol. 15, No. 2, 2003, p. 47-56.

14. J. Forrai, G. Kirschner (2003), *An Interdisciplinary 3D Cadastre Development Project in Practice,* In proceedings FIG Working Week 2003, Paris, France.

15. P. van Oosterom, C. Lemmen (2001), *Spatial Data Management on a Very Large Cadastral Database,* Computers, Environment and Urban Systems 25(2001) p. 509-528.

16. www2.swisstopo.ch (2003), *Country report 2003. The Netherlands,* PCGIAP-Cadastral Template 2003.

17. P. van Oosterom, C. Lemmen, T. Ingvarsson, P. van der Molen, H. Ploeger, W. Quak, J. Stoter, J. Zevenbergen (2005), *The core cadastral domain model,* CEUS 482, 15 february 2006.

Appendix A: Glossary & abbreviations**.**

Terminology	Descriptions	Source
1 Boundary	Either the physical objects marking the limits of real property or an imaginary line or surface marking the division between two legal estates. Also used to describe the division between features with different administrative, legal, land use, topographic, etc. characteristics.	ECE/HBP/135, 2004
2 Cadastral map	An official map showing land parcel boundaries. Cadastral maps may also show forms of land use such as buildings and may be held in digital form as a database.	ECE/HBP/140, 2005
3 Cadastre	A type of land information system that records land parcels. The term includes: Juridical cadastre: a register of ownership of parcels of land; Fiscal cadastre: a register of properties recording their value; Land-use cadastre: a register of land use; Multi-purpose cadastre: a register including many attributes of land parcels.	ECE/HBP/135, 2004
4 Cadastre	Normally a parcel based, and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyance), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection".	FIG Statement on cadastre
5 Deed	A legal document laying out the conditions under which land is transferred when the requirements of the contract are met.	ECE/HBP/140, 2005
6 Demarcation	The marking-out of the boundaries of each land parcel on the ground.	ECE/HBP/135, 2004
7 Easement (erfdienstbaarheid)	A right enjoyed by one real property (the dominant tenement) over that of another (the servient tenement) for instance a right of access or for the passage of water or electricity. The right is regarded as existing for the benefit of the land itself in favour of which the right has been given and accordingly will not be extinguished if there is a change in ownership.	ECE/HBP/140, 2005
8 Emphyteusis (erfpacht)	The holding of perpetual rights subject to an annual payment to the proprietor.	ECE/HBP/135, 2004
9 Land	The surface of the Earth, the materials beneath, the air above and all things fixed to the soil.	ECE/HBP/135, 2004
10 Land Administration	The processes of determining, recording and disseminating information about the ownership, value and use of land when implementing land management policies.	ECE/HBP/140, 2005
11 Land Parcel	An area of land with defined boundaries, under unique ownership and with homogeneous real property rights.	ECE/HBP/140, 2005
12 Land registration	The process of recording rights in land either in the form of registration of deeds or else through the registration of title to land so that any person acquiring a property in good faith can trust in the information published by the registry.	ECE/HBP/140, 2005
13 Land tenure	The mode of holding rights in land.	ECE/HBP/135, 2004
14 Land use	The manner in which the land is exploited, including the nature of the vegetation upon its surface. National governments place restrictions on the way in which land can be used through regulations the nature of which is dependent on whether the land is rural or urban. Town planning regulations, for example, define zones of activity (industrial, commercial, residential) and impose building codes that inhibit the choice of a landowner. Environmental legislation may restrict what can be done with agricultural or other forms of rural as well as urban land.	ECE/HBP/135, 2004
15 Mutation	The division of land parcels into smaller areas, for instance as a result of inheritance or commercial development.	ECE/HBP/140, 2005
16 Ownership	The most comprehensive right a person can have with respect to a thing. Full ownership includes the exclusive right to use and dispose of the thing.	ECE/HBP/140, 2005
17 Parcel identifier	A unique reference that identifies a parcel in a cadastre.	ECE/HBP/140, 2005
18 Property	That which is capable of ownership, either in the form of real property or personal property, tangible (e.g. land) or intangible (e.g. goodwill).	ECE/HBP/140, 2005
19 Real estate	Land-related property.	ECE/HBP/135, 2004
20 Real property	Land and any immovable things attached to the land including buildings, apartments and other construction and natural objects such as trees.	ECE/HBP/135, 2004
21 Registration of deeds	A system whereby a register of documents is maintained relating to the transfer of rights in land.	ECE/HBP/135, 2004
22 Registration of title	A system whereby a register of ownership of land is maintained based upon the land rather than on people (the owners) or documents (the deeds of transfer).	ECE/HBP/135, 2004
23 Right of way	The right to cross property to go to and from another parcel.	dictionary.law.com
24 Servitude (erfdienstbaarheid)	From Roman law, referring to rights of use over the property of another; a burden on a piece of land causing the owner to suffer access by another. An easement is type of servitude (easement which allows the holder to enter the land of another and to take some natural produce such as mineral deposits, fish or game, timber, crops or pasture).	www.duhaime.org

25 Servitude	A servitude is a charge imposed upon an immoveable thing, the servient property, in favour of another immoveable thing, the dominant property	Stoter, Zevenbergen
26 Spatial referencing	The association of an entity with its absolute or relative location.	ECE/HBP/140, 2005
27 Subservient tenement	Land over which there is an easement in favour of the dominant tenement.	ECE/HBP/140, 2005
28 Superficies (Opstalrecht)	Superficies is the right to use the land of another person with the object of owning thereon a structure, other work or trees. It is a right over things existing on the land owned by another person for the purpose of using such land, and is by nature a type of usufruct.	
29 Superficies	Right of building, i.e. the right to erect buildings under, on or above land owned by a third party.	Stoter, Zevenbergen
30 Title	The evidence of a person's right to real property.	ECE/HBP/135, 2004
31 Title deeds	Documents giving evidence of title to land.	ECE/HBP/135, 2004
32 Usufruct (vruchtgebruik)	The restricted right by which a person is entitled to use and to enjoy the fruits of a property that is owned by another person. From ancient Roman law (and now a part of many civil law systems), "usufruct" means the rights to the product of another's property. For example, a farmer may give a right of "usufruct"of his land to a neighbour, thus enabling that neighbour to sow and reap the harvest of that land.	ECE/HBP/140, 2005

Abbreviations	Descriptions
AHN	Actual Height Model of the Netherlands
AKR	Automated Cadastral Registration
CCDM	Core Cadastral Domain Model
DBMS	Database management system
Kadaster	Dutch Cadastre, Land Registry and Mapping Agency
LKI	Information System for Surveying and Mapping
LNW	Cable & pipeline network
MS	MicroStation
MS GG	MicroStation GeoGraphics
OS	Oracle Spatial
UNFAO	Food and Agriculture Organization of the United Nations

Appendix B1: Batch file to set up the classpath environment variables.

```
SET ORA=C:\oracle\ora92\
SET MS=c:\progra~1\Bentley\Program\MicroStation\jmdl\
SET GG=c:\progra~1\Bentley\Program\GeoGraphics\jmdl\
SET DU=c:\du\java\lib\

SET CLASSPATH=.
SET
CLASSPATH=%CLASSPATH%;%ORA%jdbc\lib\classes12.jar;%ORA%jdbc\lib\nls_charset12.jar;%ORA%lib\xmlparserv2.jar;%
ORA%sdoapi\sdoapi.zip
SET CLASSPATH=%CLASSPATH%;c:\oracle\sdoapi.jar
SET
CLASSPATH=%CLASSPATH%;%MS%;%MS%lib\bentley.jar;%MS%lib\bentleyx.jar;%MS%lib\jmdlsdk.jar;%MS%lib\rt.jar;%MS
%lib\ojdbc14.jar;%MS%lib\classes12.jar
SET CLASSPATH=%CLASSPATH%;%GG%;%GG%lib\bentleygeo.jar;%GG%lib\sdodgn.jar;%GG%lib\spatialviewer.jar
SET CLASSPATH=%CLASSPATH%;%DU%;%DU%sdodgn.jar
SET CLASSPATH=%CLASSPATH%;L:\project\jmdl\
```

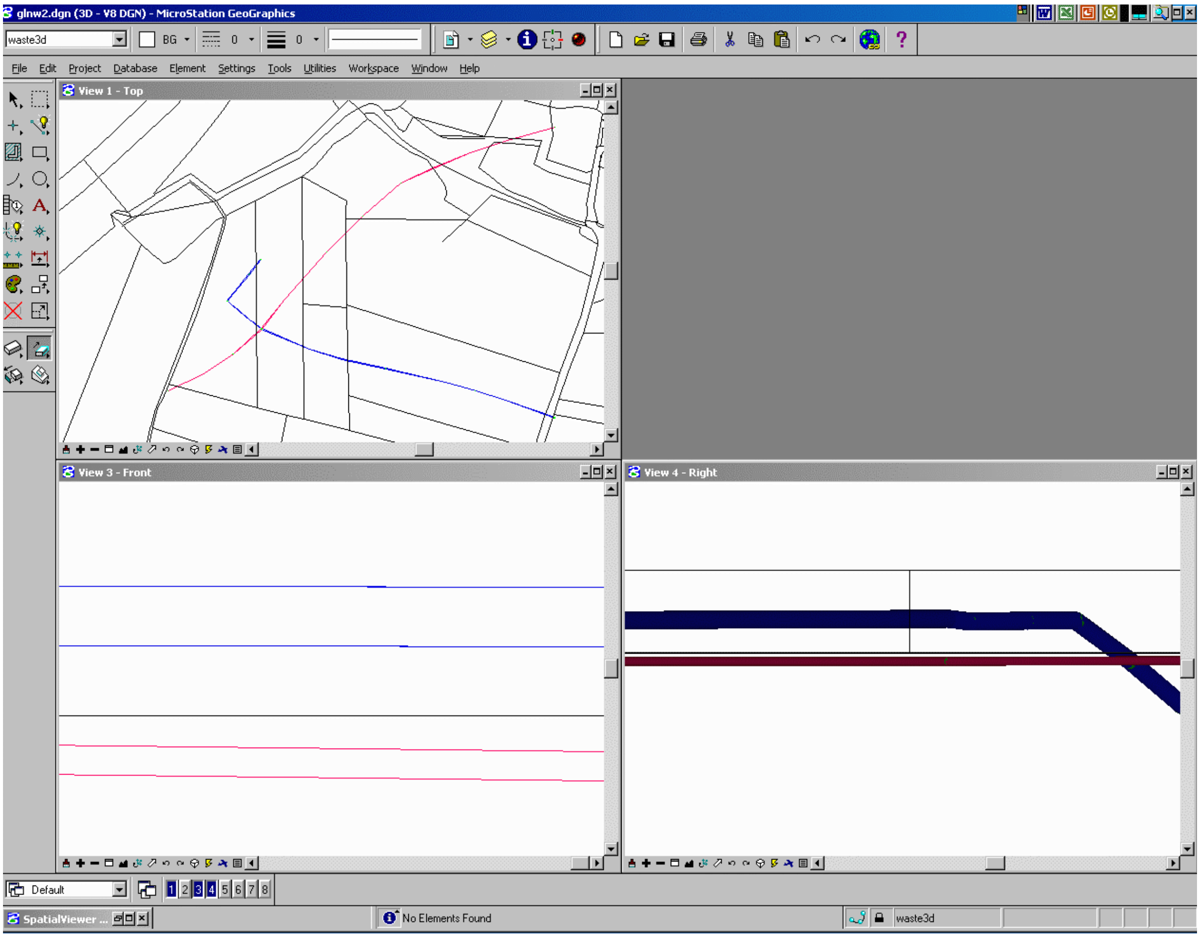
Appendix B2: SQL scripts to update MBR, initialize metadata & create indexes for network data.

```
--  Update mbr_geometry into LNW_LINE

CREATE OR REPLACE VIEW mbr (lnw_line_id, mbr_geometry)
    AS SELECT lnw_line_id, sdo_aggr_mbr(geometry) from lnw_line group by lnw_line_id;
UPDATE LNW_LINE a SET mbr_geometry = (SELECT mbr_geometry
   FROM mbr WHERE lnw_line_id = a.lnw_line_id);

-- Initialize metadata and create indexes
--  unique index: lnw_node_id, lnw_line_id
--  index:        lnw_line.geometry & lnw_line.mbr_geometry


INSERT into user_sdo_geom_metadata values ('LNW_LINE','GEOMETRY',
       mdsys.sdo_dim_array(mdsys.sdo_dim_element('X',137700000,138300000,0.002),
                      mdsys.sdo_dim_element('Y',417500000,418000000,0.002),
                      mdsys.sdo_dim_element('Z',6000,11000,0.002),
                      mdsys.sdo_dim_element('G',6000,11000,0.002)), NULL);
INSERT into user_sdo_geom_metadata values ('LNW_LINE','MBR_GEOMETRY',
       mdsys.sdo_dim_array(mdsys.sdo_dim_element('X',137700000,138300000,0.002),
                                   mdsys.sdo_dim_element('Y',417500000,418000000,0.002),
                      mdsys.sdo_dim_element('Z',6000,11000,0.002),
                      mdsys.sdo_dim_element('G',6000,11000,0.002)), NULL);

CREATE unique index LNW_NODE_INDEX on LNW_NODE(lnw_node_id) compute statistics;
CREATE unique index LNW_LINE_INDEX on LNW_LINE(lnw_line_id) compute statistics;
CREATE index LNW_LINE_GEOM_INDEX on LNW_LINE (geometry) indextype is mdsys.spatial_index;
CREATE index LNW_LINE_MBR_INDEX on LNW_LINE (mbr_geometry) indextype is mdsys.spatial_index;
CALL analyze_rtree ('LNW_LINE_GEOM_INDEX');
CALL analyze_rtree ('LNW_LINE_MBR_INDEX');
```

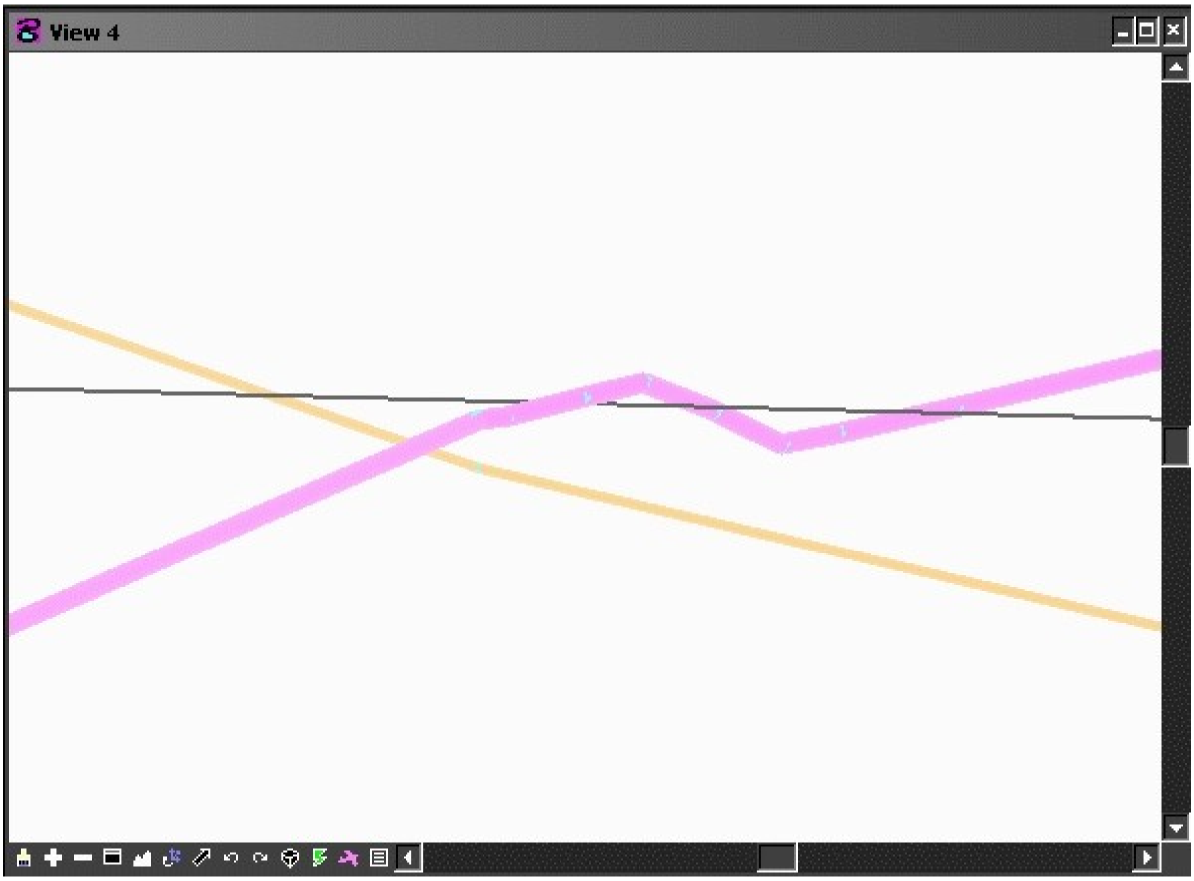
Appendix B3: SQL scripts to convert 4D geometry to 2D, concatenate multiline to a single line and add buffer to the concatenated centreline.

```
-- Stored procedure / function
-- Input: geometry in 4 dimensions
-- Output: geometry in 2 dimensions
-- Use: select transform4d2d(<geometry_column>) from <table_name>

create or replace function transform4d2d (geom in mdsys.sdo_geometry) return mdsys.sdo_geometry as
   new_geom mdsys.sdo_geometry;
   new_ordinates mdsys.sdo_ordinate_array := mdsys.sdo_ordinate_array();
   i pls_integer;
   what_to_do boolean := false;
begin
   -- 1:   create function transform4d2d

   -- 2:   concatenate multilines into a single line
   --      select sdo_aggr_concat_lines(transform4d2d(lnw_line_id)) from lnw_line where lnw_uin = 88;

   -- 3:   create temporary view table for concatenated line with buffer of half the diameter
   --      create view tmp_buffer
   --      as select lnw_uin,
   --         sdo_geom.sdo_buffer(sdo_aggr_concat_lines(transform4d2d(geometry)), max(diameter) / 2, 0.01) shape,
   --         sdo_aggr_mbr(transform4d2d(mbr_geometry)) mbr_geometry
   --      from  lnw_line
   --      group by lnw_uin;

   -- 4:   insert into metadata table to be able to select from MicroStation
   --      insert into user_sdo_geom_metadata values ('TMP_BUFFER','SHAPE',
   --         mdsys.sdo_dim_array(SDO_DIM_ELEMENT('X', 137700000, 138300000, .002),
   --         SDO_DIM_ELEMENT('Y', 417500000, 418000000, .002)),null);

   -- 5:   query the view [= pipe/cable] / parcels for spatial interactions
   --      select object_id, geom from parcelasgeom_test where sdo_relate(geom,
   --        (select shape from tmp_buffer where lnw_uin = 88),
   --        'mask=covers+contains+overlapbdyintersect, querytype=window') = 'TRUE';

   -- dbms_output.put_line('Coordinate count ' || geom.sdo_ordinates.count);

   -- for i in 1 .. geom.sdo_ordinates.count

   i := 1;
   while i <= geom.sdo_ordinates.count
   loop
      --dbms_output.put_line('Counter: ' || i);
      --dbms_output.put_line( geom.sdo_ordinates(i) );

      new_ordinates.extend(1);
      new_ordinates(new_ordinates.last) := geom.sdo_ordinates(i);

      if what_to_do = false then
         i := i + 1;
         what_to_do := true;
      else
         i := i + 3;
         what_to_do := false;
      end if;
   end loop;

   new_geom := geom;
   if geom.sdo_gtype = 4002 then
      new_geom.sdo_gtype := 2002;
   elsif geom.sdo_gtype = 4003 then
      new_geom.sdo_gtype := 2003;
   end if;
   new_geom.sdo_ordinates := new_ordinates;

   return new_geom;
end;
```

Appendix C1: Snapshot of 3D visualization
View 1: Plan showing cable, pipeline & parcels
View 3: Vertical section showing cable & pipeline without rendering, and parcel
View 4: Vertical section showing rendered cable & pipeline and extruded parcel



Appendix C2: Snapshot of 3D visualization
Vertical section showing cable, pipeline and parcel in various elevations.



Appendix D: Internship daily logbook.

Stage Daily Logbook

Month	Day		From	To	Day total	Week total	Remark
Oct 05	10	Mon	9:30	12:30	3:00		Presentation: Du - 3D Pipeline System, then discussion with Du.
	14	Fri	10:00	12:00	2:00	5:00	Placement meeting with ir Friso, then discussion with Du.
	24	Mon	8:30	17:30	9:00		Search for literature - Dutch cadastre, 3D Cadastral.
	25	Tue	8:30	17:30	9:00		Problem definition, project planning (draft work plan). Submit 1st draft of time schedule.
	26						
	27	Thu	8:30	19:00	10:30		Search for literature (Dutch LIS). Draft work plan, review time schedule. Submit final draft to Friso.
	28	Fri	8:30	17:30	9:00		Search info: Kadaster.nl.
	29	Sat	20:00	22:30	2:30	40:00	Reading: 3D cadastre.
	30						
	31	Mon	8:30	17:30	9:00		Understand Dutch cadastre.
Nov 05	1	Tue	8:30	17:30	9:00		Search info: representation of 3D objects.
	2						
	3	Thu	8:30	18:00	9:30		Search info: Cadastre 2014.
	4	Fri	8:30	17:30	9:00		Search info: legal aspects.
	5	Sat	19:30	23:00	3:30	40:00	Reading: 3D cadastre.
	6						
	7	Mon	8:30	17:30	9:00		Discussed work plan with Friso. Editing work plan, discussion with Aegidius on Dutch's piping.
	8	Tue	8:30	17:30	9:00		Check Nr 36.075 ruling. Search info: KLIC, amendment to work plan. Resubmit work plan.
	9						
	10	Thu	8:30	18:00	9:30		Friso ok work plan. Draft report on Cadastre.
	11	Fri	8:30	17:30	9:00		Work from home - dentist appointment.
	12	Sat	19:30	23:00	3:30	40:00	Reading: 3D cadastre.
	13						
	14	Mon	8:30	17:30	9:00		Compile information on 3D cadastre.
	15	Tue	8:30	17:30	9:00		Compile information on Oracle Spatial & MicroStation GeoGraphics.
	16						
	17	Thu	8:30	18:00	9:30		Write concepts of Oracle Spatial & MicroStation GeoGraphics.
	18	Fri	8:30	17:30	9:00		Synchronized terminology (ECE/HBP/135 & 140).
	19	Sat	19:30	23:00	3:30	40:00	Land administration: Platt 1975.
	20						
	21	Mon	8:30	17:30	9:00		Legal cadastral domain model
	22	Tue	8:30	17:30	9:00		Administrative cadastral data is fun & generic query tool for spatio-temporal data.
	23						
	24	Thu	8:30	18:00	9:30		Dutch geometric & administrative data model.
	25	Fri	8:30	17:30	9:00		3D partition & registration of subsurface space. Discussion with Peter (4.00~4:40).
	26	Sat	19:30	23:00	3:30	40:00	Draft minute 25,11,05.
	27						
	28	Mon	8:30	17:30	9:00		Prepared minute 25,11,05. Study GISt No 1.

	29	Tue	8:30	17:30	9:00		System of land registration - aspects & effects.
	30						
Dec 05	1	Thu	8:30	18:00	9:30		Understand common land legal terminology (UNECE 135/140).
	2	Fri	8:30	17:30	9:00		Morning GIMA 1st presentation at UU. > 12.30 back at OTB. Request installation of OS & MSGG.
	3	Sat	19:30	23:00	3:30	40:00	
	4						
	5	Mon	8:30	17:30	9:00		Read Du's 3D visualization of UPIS.
	6	Tue	8:30	17:30	9:00		Read Du's 3D visualization of UPIS.
	7						Theo installed Oracle Spatial & MicroStation GeoGraphics.
	8	Thu	8:30	18:00	9:30		Explore Oracle Spatial & MicroStation GeoGraphics, read OS manual.
	9	Fri	8:30	17:30	9:00		Work from home - dentist follow-up appointment (9:55 & 17:10). Theo gave user ID & p/w, host string.
	10	Sat	19:30	23:00	3:30	40:00	
	11						
	12	Mon	8:30	17:30	9:00		Learn Oracle Spatial - basics.
	13	Tue	8:30	17:30	9:00		Wrong date (Christiaan at OTB on 14.12,05 not 13.12.05). Chapter 2 Oracle Spatial User's Guide.
	14						Vladimir's presentation. Failed to meet Christian Lemmen.
	15	Thu	8:30	18:00	9:30		Read 3166 coding of administrative districts.
	16	Fri	8:30	17:30	9:00		Learn Oracle Spatial - loading spatial data.
	17	Sat	19:30	23:00	3:30	40:00	Reading through 3DUPIS.
	18						
	19	Mon	8:30	18:00	9:30		Re-read 3DUPIS with Du.
	20	Tue	8:30	18:00	9:30		Understand 3DUPIS piping database table structure.
	21	Wed	8:30	17:00	8:30		Going through UPIS database.
	22	Thu	8:30	18:00	9:30		Visit Chris at Apeldoorn (13.05).
	23	Fri	8:30	17:30	9:00		Kadaster databases (from Chris Lemmen).
	24	Sat				46:00	
	25						
	26	Mon	Christmas & New Year Holidays.				
	27	Tue	Christmas & New Year Holidays.				
	28	Wed	Christmas & New Year Holidays.				
	29	Thu	Christmas & New Year Holidays.				
	30	Fri	Christmas & New Year Holidays.				
	31	Sat	Christmas & New Year Holidays.				
Jan 06	1						
	2	Mon	8:30	18:30	10:00		Tidy up new office.
	3	Tue	8:30	18:30	10:00		Land use and society.
	4	Wed	8:30	18:30	10:00		Study GRENS_LEIDINGNETWERK_CMD (Kadaster's proposed pipeline data structure).
	5	Thu	8:30	18:30	10:00		Friso: Topology.sql + Feature.sql (to load ECK00 LKI data to Oracle 10g).
	6	Fri	8:30	18:00	9:30		Friso: Retrieve.sql (to retrieve parcels from LKI). Installed Exceed onDemand Client - no connection to www.gdmc.nl:5500 (Theo to check).
	7	Sat	19:30	23:00	3:30	53:00	
	8						
	9	Mon	8:30	18:30	10:00		Oracle 10g Topology. Exceed onDemand Client - not working.
	10	Tue	8:30	18:30	10:00		Retrieve/Topology/Feature.sql. Exceed onDemand Client - not working. Submit brief progress report.
	11						

	12	Thu	8:30	18:00	9:30		Run the 3 scripts from Windows, Node & Face tables empty (consult Friso). Exceed not working.
	13	Fri	8:30	18:30	10:00		Reload another version of Exceed, also WS_FTP95 Pro. All ok. Errors in Topology.sql. Theo: errors due to Test_Municip = NDH02, not ECK00.
	14	Sat	19:30	23:00	3:30	43:00	
	15						
	16	Mon	8:30	19:00	10:30		Re-worked on LKI to Oracle transformation (Theo xfer lki datasets no longer in working directory, work around by adding KADTEST link. Details see log files).
	17	Tue	8:30	19:00	10:30		Marian confirmed Peter as GIMA supervisor, printed 4 sets documents. Submitted to Peter (copy to Stan via Peter). KLI data has ORA-04063 error, informed Theo.
	18						
	19	Thu	8:30	19:15	10:45		Returned Land Use Control to library. ORA-04063 errors: Theo re-load filtered raw data from KADTEST to KADNL2, re-run scripts, ORA-04063 error solved.
	20	Fri	8:30	19:30	11:00		Validate geometry of LKI_parcel using sdo_aggr_union, sdo_geom.sdo_area/length & perform consistency check sdo_geom.validate_geometry_with context. Informed Theo about missing "msgeo.cfg" file.
	21	Sat				42:45	
	22						
	23	Mon	8:30	19:30	11:00		Scrutinize Du's mjava files for water, communication and power line.
	24	Tue	8:30	19:00	10:30		Modified PipAttachLine.mjava.
	25						
	26	Thu	8:30	19:00	10:30		Prepared progress report for tomorrow meeting.
	27	Fri	8:30	18:30	10:00		Meeting with Peter, Theo (27,1,06 11:00-13:00). MS's license issue solved (Theo).
	28	Sat				42:00	
	29						
	30	Mon	8:30	18:30	10:00		Registration of cross-boundary infrastructure object in detail.
	31	Tue	8:30	17:30	9:00		Proposed registration of wayleave, conceptual model & data structure.
Feb 06	1						
	2	Thu	8:30	18:00	9:30		Drafted GLNW logical model & data structure, send copy to Theo to ask for discussion. Asked Sisi to demon Du's system - discovered MS not working. Theo re-installed at 17:40.
	3	Fri	8:30	17:30	9:00		Environment setting for MicroStation GeoGraphics - not successful. Sisi showed how to created DGN file from existing file.
	4	Sat	19:30	23:00	3:30	41:00	Simulate Node & Line data from AutoCAD & Excel.
	5						
	6	Mon	8:30	19:00	10:30		(~~Meeting with Kadaster (6/2/06 13:00)~~). Insert data into Node & Line tables.
	7	Tue	8:30	18:30	10:00		Environment setting: MS GG project set-up - (not working). Set up consultation with Sisi on Thu 10:00 (9.2.06).
	8						
	9	Thu	8:30	18:30	10:00		Compiled mjava file under DOS.
	10	Fri	8:30	18:30	10:00		Meeting with Peter, Theo (10,2,06 14:00). Edit mjava file.
	11	Sat	0:00	0:00	0:00	40:30	
	12	Sun	11:00	13:00	2:00		Draft UML diagram for node & line.
	13	Mon	9:00	18:30	9:30		Compiled mjava file under DOS, investigating the SetClassPath variables in Du's personal library, Oracle, MicroStation & GeoGraphics. Prepared a batch file for the classpath setting.

	14	Tue	8:30	19:00	10:30		Tried to load the compiled bytecode into MicroStation, Encountered errors from the setclasspath environment settings, also the incompatibility of data linetype (Gtype 4002) with the simulated data (Gtype 3002). Add-in additional z-coordinates for all nodes (vertices inclusive).
	15	Wed	10:00	11:00	1:00		Amend UML diagram.
	16	Thu	8:30	19:00	10:30		Reworked on the batch file & investigate compilation errors (program no longer work). Detected errors in the amended MJAVA file, still there are errors in MS - ORA 12541 (Oracle server down).
	17	Fri	8:30	18:45	10:15		Redo compilation & load bytecode into MS. Discussed indexing issues with Theo, also about finding spatial interaction between pipeline & parcels, then assign z (surface level) to parcels.
	18	Sat				41:45	
	19						
	20	Mon	8:30	18:30	10:00		Discussed with Friso (find sdo_anyinteract & assign z(ground level) to identified parcels).
	21	Tue	8:30	18:00	9:30		Modified lnw_node & lnw_line tables.
	22						
	23	Thu	8:30	18:00	9:30		Explore Oracle Spatial 3D operators, utilities etc.
	24	Fri	8:30	18:00	9:30		Meeting with Peter & Friso, elaboration on UML diagram. Draft minutes.
	25	Sat			0:00	38:30	
	26						
	27	Mon	8:30	18:15	9:45		Prepared minutes, draft UML diagrams (2 options) & draft TOC.
	28	Tue	8:30	19:00	10:30		Worked with Sisi to retrieve LKI parcels into MS, then to raise parcels to surface level.
Mac 05	1						
	2	Thu	8:00	19:00	11:00		Draft presentation slides.
	3	Fri	8:00	18:00	10:00		Draft presentation slides, create indexes for KADASTER (=kadaster_test_edge$ with RL_GROUND = 9.120 inserted by Sisi). Prepare snapshots for demo.
	4	Sat			0:00	41:15	
	5						
	6	Mon	8:30	18:45	10:15		Draft chapter 1
	7	Tue	8:30	18:45	10:15		Draft chapter 2 & 3.
	8						
	9	Thu	8:30	18:45	10:15		Draft chapter 3 & 4.
	10	Fri	9:00	14:45	5:45		Work from home (informed Friso 6.3.06). Chapter 5.
	11	Sat	19:30	23:00	3:30	40:00	
	12						
	13	Mon	8:15	18:45	10:30		Meeting 13:00 - 14:00. Redraft Chapter 1.
	14	Tue	8:15	18:45	10:30		Incorporate work placement plan into new chapter 2.
	15						
	16	Thu	8:15	18:45	10:30		Redraft Chapter 4 .
	17	Fri	8:00	18:45	10:45		Redraft Chapter 6 .
	18	Sat	19:30	23:00	3:30	45:45	Revision whole report & presentation slides.

Grand Total (hours) : 842:30

Appendix E1: Minutes of discussion

Discussion on stage project: Registration of Piping (cables & pipelines) as Real Property

Minutes of the meeting
Friday 25th Nov 2005, 16:00 ~16:40

Present: Peter Oosterom
Chong SC

Apologies:

Minutes

Item 1 **Introduction: Dutch's Kadaster** **Action**

Peter begun the discussion by briefly explaining the roles and set up of Kadaster. It has 15 regional offices, each maintaining its set of RDBMS - LKI for geometry and topology of parcels (from cadastral map and GBKN). Another IDMS database on IBM mainframe maintains the AKR - for legal and other administrative data (from deeds register) related to the parcels. Info

These 2 RDBMSs are loaded twice a year into a single Ingres DBMS for analysis, query and filter, to enable analysis and performing consistency checks on the cadastral source data to improve its quality.

System walk-through: Query tool "Kadnl.geo"

Peter mentioned that there are 3 types of register-able real property - parcel, part of parcel and apartment. LKI the geometric DBMS consists of 6 main tables - boundary (cadastral boundaries), parcel (parcel identifiers), symbol (cartographic symbols), GCP (geodetic control points), line (topographic lines) and text (e.g. street name). Historical data is also included to provide the time stamp or temporal information. AKR contains information based on the concepts of real estate object (object), person (subject) and right or restriction. Info

The query tool has its own database (copy of all geometric and administrative data in its original data models). There are separate user interfaces to query LKI or AKR individually or in combination (also a different user interface to query and update at Kadaster HQ). LKI provides the geometry only for the ground parcel, while descriptions on the part of parcel, apartments complex and its individual apartments are available in the AKR.

The nationwide unique parcel identifier consists of a municipality code, a section code, base parcel number and index. This record is maintained in both RDBMSs, thus provides the required linkage between the 2.

Winged-edge structure of the geometric model

LKI stored no polygon of parcel, but edge of parcel boundaries with topology via the chain-method. Edges contain 4 references to other edges to indicate immediate left and right edge at the first point, and also the immediate left and right edge at the last point. Further reference from a face to the first edge of its boundary chain if island is present. Explicit storing of topological reference enable checking of topological structure, as well as convenient for data manipulation (e.g. polygon construction). Info

Kadaster is in the process of converting the 2 DBMSs into Oracle Spatial database, thus polygon reconstruction no longer need outside function, but computed directly from the database instead.

Item 2 **Underground piping (cables & pipelines) as register-able real property**

The Supreme Court ruling on telecom cables (Hoge Raad der Nederlanden Nr.36.075, 6.6.2003 - A cable television network is an independently transmissible property matter) paved the way that the rights on cables and pipelines are to be registered. Kadaster is now is required to register piping as the 4th register-able real property. Info

	The current practice of registration via the attachment of drawings (i.e. via legal notification of OB - underground construction) only indicates factual indication of underground object beneath the surface. Whatever rights or restrictions are still registered on the surface parcel.	
	Issues to be consider:	
	1. As a 4th register-able real property, piping need legal as well as geometric descriptions. LKI store piping centreline as topographic line, AKR attached its rights and restrictions?	SC
	2. Piping centrelines to be recorded into the existing topographic data? How about the new attributes such as size of piping, its feature (e.g. valve, hydrant). depth etc.?	SC
	3. Piping records stored in existing table or a separate table? Existing attributes might not be sufficient.	SC
	4. How to identify piping? To extend from the existing parcel identifier (for parcel, part of parcel & apartment) or a new set of unique ID?	SC
	5. How to record depth? A relative or absolute RL (level reduced to NAP)?	SC
Item 3	**Proposed solution**	
	As Kadaster is switching to Oracle Spatial, suggested to use Oracle Spatial for database management and MicroStation GeoGraphics for analysis and visualization.	Info
Item 4	**Processes:**	
	1. Locate a test area, e.g. area with NAM pipelines. Convert the cadastral map from Ingres to Oracle Spatial 10g.	Friso & SC
	2. Install OS and MicroStation GeoGraphics.	Theo & SC
	3. Incorporate the pipeline modelling scheme of Du's work for storing pipeline and visualization (includes the parcel).	SC, Du & Friso
	4. Prototyping	SC
Item 5	**Arrange next discussion**	SC, Du & Friso
	Closed at 16:40	

Appendix E2: Minutes of discussion

Discussion on stage project: Registration of Wayleave (cables & pipelines) into Dutch Cadastre

Minutes of the meeting

Friday 27th Jan 2006, 11:00 ~13:00

Present: Peter Oosterom <P.v.Oosterom@otb.tudelft.nl>
Theo Tijssen <T.Tijssen@otb.tudelft.nl> (alternate for Friso)
Chong SC

Apologies:

Minutes

Item		Action
Item 1	**Work Placement Plan**	
	Peter commented on the following:	
	a. 6th paragraph of Section 1.2 Introduction. The external module was not for the purpose of maintenance, but provided the linkage between the geometry (LKI) & administrative (AKR) databases during loading.	SC
	b. Section 2.3 - incorporation of AHN data. SC replied that this no longer applicable as time is running short.	Info
	c. Section 2.4 - Whole & part registration. Peter asked to define whole & part issue. SC clarified that the registration required information on pipeline network as a 'whole', and individually there is a 'OB' tag to indicate the presence of pipeline. Peter further asked to investigate the pros and cons of maintaining pipeline network explicitly, over the implicitly registration of other real properties such as parcel, part of parcel and apartment.	SC
	d. Section 2.4 - Representation of pipeline. Peter asked to clarify the use of absolute and relative height for the geometric segments and nodes, also asked to cater for absolute height during modelling. SC clarified that both the geometric segments and nodes represent absolute height, but the relative height (depth) will also be provided for practical purposes (e.g. for maintenance works etc.).	SC
	e. The time schedule was rather tight, without taking into Christmas & New Year holidays.	Info
	f. Section 3.2 - Hardware and Software. Peter pointed out that there are more software that being used (than the stated 2). SC informed that Hummingbird Exceed was being used instead of the local SQL Plus, because SQL Plus won't work on large scripts (multiple lines with many spaces in between). Theo further added that he was informed by Friso on this, but has no idea how this happen.	Info
	g. The time schedule was rather tight, without taking into Christmas & New Year holidays.	Info
Item 2	**Progress review**	
	Peter commented that the progress is rather unsatisfactory, the scheduled prototype on Jan 20 is not yet ready, the following issues are then discussed in detail:	All
	a. Transformation of lki to Oracle. SC pointed out that the process took far longer time than anticipated due to the following:	Info
	- the local SQL Plus don't permit multilines scripts, need to installed Exceed.	
	- the transfer of data server from OTB old building further delayed the installation of Exceed, as the first version installed is not working and Theo is looking for another workable version.	
	- the SQL scripts gave errors as the test data prepared by Theo was collected from NDH02, but Friso had chosen ECK00 instead. Also the scripts need to be modified (provided with the required linkage) as the tested environment was not the same as SC's.	

- the second data was also not in order, gave error message ORA-04063: type body "MSSYS.SDO_GEOMETRY has errors. Theo has to re-collected the lki dataset again, then transferred to KADNL2.

- the 3rd attempt of transformation was proved to be correct after running the geometry consistency validation.

b. Proposed GLNW data structure
SC clarified that the proposed data structure submitted during the previous submission on Jan 10 was meant for further discussion with Friso. Peter further suggested that to work on the conceptual model prior to further elaboration, as there are many unresolved issues. — SC

Item 3 Other Issues

a. Peter mentioned that parcel table is not needed as the polygon can always construct from polygon. Theo informed that the face (hence parcel) table was created to check its geometry. — Info

b. Peter recommended that it will be better alternative to incorporate wayleave data into existing LKI & AKR databases, then there will be consistent will the three other real objects (parcel, part of parcel & apartment, still of separate database outside the existing system. — SC

c. How to provide identifier to pipelines - similar to 'municipality-code + section + parcel number' ? — SC

d. To consider time stamp (temporal) for pipeline data - SC was of the opinion that it can be included in the model, but not in this prototype (with simplified environment). — SC

e. Peter highlighted that this research should demonstrate that it provided added 'value' on top of the similar projects by Friso (Oracle 10g Topology) & Du (3D Visualization of Pipelines), — SC

f. Peter pointed out that there should be more concerted efforts and frequently meetings to trash out issues in order to catch up with the lost time. — Info & SC

Item 4 Proposed next discussion on Jan 10, 06 at 11:00. — All

Closed at 13:00

Appendix E3: Minutes of discussion

Discussion on stage project: Registration of Wayleave (cables & pipelines) into Dutch Cadastre

Minutes of the meeting
Friday 10th Feb 2006, 14:00 ~15:00

Present: Peter Oosterom <P.v.Oosterom@otb.tudelft.nl>
Theo Tijssen <T.Tijssen@otb.tudelft.nl> (alternate for Friso)
Chong SC

Apologies:

Minutes

Item 1	**Kadaster's Grens_LeidingNetWerk_CMD**	**Action**
	Peter informed that Kadaster forwarded the following:-	
	a. Grens_LeidingNetWerk_CMD - proposed data structure of the cable & pipeline dated 16 Nov 2005.	
	Chong informed that this version is identical to the previous version furnished by Chris. The proposed data structure was modified basing on the same requirements.	Info
	b. Sample data.	
	Chong informed that there were 4 set of data, for EuroFiber - Utrecht-Arnhem-Apeldoorn, TUD - netwerk Delft, Eneco - netwerk province Utrecht & vs - telecom Nuenen. These real life data will only be incorporated if time is permitted. Right now only simulated data is being introduced in the testing.	SC
	(Remark: Theo suggested that use FME (feature manipulation engine, an universal translator) to convert these MapInfo import/export file to Oracle. Forwarded the email from Peter to Theo for his further action).	Theo/SC
Item 2	**Progress review**	
	Chong reported that the transformation of LKI data & the adaptation to Du's MJAVA file had been completed. Based on the research on the concepts and various studies, the proposed 3D cadastre for this study shall adopt the Hybrid 2D/3D approach (details refer brief report submitted). The following tasks are still in process:-	Info
	a. Compilation of MJAVA file.	
	Encountered error messages such as - "no package, source or class file found for com.bentley.dgn & oracle/spatial". Apparently there are a series of CLASSPATH environment variables to direct Java Virtual Machine & other Java applications for the required (inclusive also the user defined) class libraries. There is no record on the various setting from Du's report & no batch file is located within the local or network drives, the process of locating the required paths for the relevant .zip or .jar files is still on-going.	SC
	b. Import of LNW nodes and lines into MicroStation GeoGraphics.	
	Can only proceed pending the compilation of the required MJAVA file (to MCLASS file).	SC
	c. Create LKI parcels on the fly (within MicroStation GeoGraphics).	
	Still pending, will source for the available scripts within OTB.	SC/Theo
	d. Assign z-coordinates to the LKI parcels	
	To accommodate the current system of cadastral registration, the reduced levels at the ground level are provided only at the LNW network. Absolute height is used in the Node & Line geometries and also at the ground level (vertically above the nodes and vertices). The surface parcels will be vertically projected upwards, by assigning the RL_GROUND from the nearest node or vertex. The whole parcel can be projected at the centroid or at each parcel's node.	SC
Item 3	**Other Issues**	
	a. Peter is not satisfied with the progress made thus far. Issues aroused from the environment setting should be settled while Du was around.	Info

b. Chong said such observation didn't reflect the actual situations. Without the required "wares" (data - LKI & LNW, software - MicroStation GeoGraphics, tools - Exceed or Putty, little knowledge on Oracle SQL, JAVA & MicroStation GeoGraphics), he was deprived of the opportunities to learn by exploring through hand-ones. Studying the concepts and observing demonstration (under one environments) are not sufficient without doing it under individual environments. As every GI projects are different (some are similar and yet differ in many aspects), under the current circumstances, he is doing the best he can. Info

Item 4 **Proposed next discussion on Feb 24, 06 at 11:00.** All

Closed at 15:00

Appendix E4: Minutes of discussion

Discussion on 'stage' project: Registration of Wayleave (cables & pipelines) into Dutch Cadastre

Minutes of the meeting

Friday 24th Feb 2006, 11:00 ~13:00

Present: Peter Oosterom
Friso Penninga
Chong SC

Apologies:

Minutes

Item 1	**UML Class Diagram**	**Action**
	The discussion begun with detailed elaboration on the proposed conceptual model. SC explained that the model was extended from Jantien's UML class diagram for the registration of 3D physical objects, taking into account Du's urban pipelines project. Also there was a slight adjustment on the LNW_LINE's polyline linetype, which was changed from Gtype 3002 (3-dimensional polyline) to Gtype 4002 (4-dimensional polyline). This was to suit Du's JMDL script (to avoid extensive modifications), the dimension are: x, y, z & z1 (absolute coordinates of node/vertices & ground level).	
a.	Peter commented that the UML class diagram is the good medium for exchanging ideas. He also proposed some modifications to the proposed model:-	
i.	Jantien's proposal was actually a half-way approach as the 3D physical objects (cable & pipeline in this topic) were then not a register-able right object. After the Supreme Court ruling Nr.36.075, Kadaster will prefer to classify cables & pipelines as 'Object', not merely as '3D physical object'.	Info
ii.	A Legal Network class was proposed to indicate association (via Legal Buffer) from 3D physical object, which has a specialization relationship with reference to CCDM's Object.	Info
b.	With reference to a point raised by Peter, Friso informed that Feature is preferred (over Parcel) as the term has been used in LKI. Feature class is required here so that attributes of the parcel can be attached. Also it contains the Sdo_topo_geometry, while in LKI, the only object is still refer as the parcel.	Info
c.	Peter suggested to look beyond Jantien's model, to do away with 'half-way' approach, to enable registration of cables & pipelines as an object, instead as a holding by a subject.	SC
i.	A sketch has been constructed for further elaboration.	SC
Item 2	**Progress review**	
	Chong reported that the import of LKI parcels into MicroStation GeoGraphics (via SQL Query) is still in progress. He further informed that there are few spatial operators relevant to 3D or more environment.	
a.	Peter suggested to refer to Sisi for assistance, and also to refer to past works in GISt report no. 7. He further informed that sdo_relate operator on 4D geometry object will return 2D geometry, which work perfectly well for this purpose.	SC
b.	Peter also informed that theory, concepts and understanding is more important aspects of this project, so if there is insufficient time for 3D visualization task, then should start working on the report.	SC
c.	Friso suggested SC to submit a draft table of content by early next week, so that the important topics are covered. A concept draft should be ready a week before the stage end, to allow sufficient time for elaboration. He further suggested that the report can begin with the elaboration on the conceptual modelling, then to proceed to the prototype development, with discussion also on the relevant technology & tools.	SC
d.	Peter suggested for a tentative date for the presentation on March 17 , at 11.00 am.	Info/SC
d.	Peter also pointed that the report shall emphasize that the LKI & LNW geometries are not stored explicitly, but can be retrieve implicitly on the fly when required, from the stored topology.	SC

Item 3	**Other Issues**	
	a. Peter explained that as the GIMA supervisor, he shall the invigilator for this stage, taking into account assessment from Friso as the stage supervisor.	Info
Item 4	**Proposed next discussion on Mar 13, 06 at 13:00.**	All

Closed at 13:00

Appendix E5: Minutes of discussion

Discussion on 'stage' project: Registration of Wayleave (cables & pipelines) into Dutch Cadastre

Minutes of the meeting

Monday 13th Mac 2006, 13:00 ~14:00

Present: Peter Oosterom
Friso Penninga
Chong SC

Apologies:

Minutes

Item 1	**Progress**	**Action**
	SC informed that the 3D visualization part of the prototype has been completed. The prototype functions include spatial analysis for 'part & whole' - identify the intersecting parcels with the cable and pipeline network (parts) & the network as a whole object (whole), 3D visualization of the parcels & cable & pipeline network to indicate the plan & cross-sectional views. The rough draft of the report and presentation slides have been forwarded last Friday for today discussion.	Info
	a. Friso handed over the copy of the draft with many comments and remarks:	
	i. General - explain everything in much more detail, so that 'outsiders' should be able to read and understand, also provide more reasoning and illustrations. Also used Dutch names of legal rights as translation is always difficult on legislation.	SC
	ii. Section 1: Introduction - what about topology in the Dutch cadastre, describe the limitations on the current cable & pipeline registration	SC
	iii. Section 2: Conceptual Model - give background information of CCDM, explain the models in greater detail.	SC
	iv. Section 4: Development of Prototype - describe node & edge diagram, explain the set up of the LNW data structure, also tell more about the model. The entire process should be described with much more details & indicate input.	SC
	v. Section 5: Conclusion - to refer to the placement plan for the goal, scope & research topics & answer the questions formulated.	SC
	b. Peter informed he has not read the draft in details, but conferred with Friso's comments. He also indicated that it is better to complete the report first. The presentation slides can come later.	
Item 2	**Other Issues**	
	a. Peter proposed that the stage be extended to prepare for the next concept draft.	Info/SC
	b. SC informed that the concept draft shall be ready in a week or two.	SC
Item 4	**No date fixed for the next discussion.**	All
	Closed at 14:00	